BUREAU OF ECONOMIC GEOLOGY
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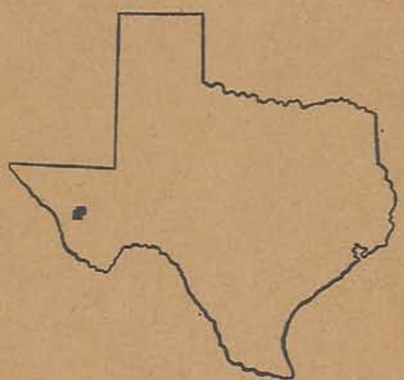
GEOLOGIC QUADRANGLE MAP NO. 36

Igneous Geology of the Central Davis Mountains, Jeff Davis County, Texas

By

JAY EARL ANDERSON, JR.



May 1968

THE UNIVERSITY OF TEXAS AT AUSTIN
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TO ACCOMPANY MAP—GEOLOGIC
QUADRANGLE MAP NO. 36

IGNEOUS GEOLOGY OF THE CENTRAL DAVIS MOUNTAINS, JEFF DAVIS COUNTY, TEXAS

JAY EARL ANDERSON, JR.[1]

1968

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ILLUSTRATIONS

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INTRODUCTION

The Davis Mountains are an erosional remnant of a volcanic field that probably covered 5 to 10 times their present areal extent of approximately 2,000 square miles. Many previous workers believed that much of the extrusive material in nearby parts of western Trans-Pecos Texas was erupted from the central Davis Mountains (Colton, 1957, p. 76; Lewis, 1949, p. 89; McAnulty, 1955, p. 543; Zabriskie, 1951, p. 36). To test this idea, petrologic, stratigraphic, and structural investigations were made in order to understand the relationships among the various extrusive and intrusive rocks in the central Davis Mountains.

The Davis Mountains are located in Jeff Davis, Presidio, and Brewster counties in Trans-Pecos Texas; this report deals with about 240 square miles in the highest part of the range. Fort Davis is approximately 10 miles east of the southern part of the map area, and Marfa is about 18 miles south of the area. Ready access is provided by State Highways 166 and 118, Spur 78, several graded county roads, and numerous unimproved ranch roads.

The Davis Mountains lie on the southeast end of the Diablo Platform of Permian age (King, 1942, p. 665–666). The Diablo Platform is bounded on the northeast by the Delaware basin, and on the southwest by the Marfa basin.

The central Davis Mountains consist of a series of soda-rich, silicic pyroclastic units and lava flows of late Eocene to Oligocene age. The volcanic rocks were intruded by stocks, sills, and dikes, mostly in the same compositional range, during the latter part of the period of eruptive activity. Thirteen volcanic units, with an aggregate thickness of approximately 2,500 feet, and six intrusive units were mapped.

The volcanic sequence includes air-fall tuff, ignimbrites, and ordinary lava flows. But most of the stratigraphic units exhibit field and petrographic features indicating a mechanism of origin that is intermediate between ignimbrites and lava flows; these units may have been spread by a *nuée ardente* type of eruption, followed by a stage of flow as viscous liquids.

The volcanic rocks are cut by high-angle normal faults of Tertiary age which generally strike NW to NNW, parallel to many of the major structural features of Trans-Pecos Texas. Displacement of most faults is down to the southwest, but there are many exceptions.

Most of the intrusions are in a zone trending about N. 30° W., approximately on strike with a similar trend of major intrusive bodies in the Big Bend depression southeast of the Davis Mountains. This major subsidence structure probably extends to the Davis Mountains and is associated with the eruption of the tremendous volume of extrusive material.

Hydrothermally silicified and kaolinized volcanic rocks are most abundant in the southwestern part of the area. Silicified rocks are not common in the northeast where kaolinite and nontronite are the most abundant hydrothermal products. The alteration pre-dates some of the youngest volcanic units and is probably associated with emplacement of the intrusions.

The earliest geological work in the Davis Mountains was a reconnaissance study by Von Streeruwitz (1890, 1893). Osann (1892, 1896) described a number of igneous rocks collected by Von Streeruwitz, recognized their alkalic nature, and mentioned their similarities to the Permian igneous rocks of the Oslo region in Norway.

The Buck Hill volcanic series in the Buck Hill quadrangle, about 30 miles south-southeast of the map area, was worked out by Goldich and Elms (1949). The Buck Hill series is recognized by McAnulty (1955) in the Cathedral Mountain quadrangle, about 20 miles southeast of the map area. Eifler (1951) described the McCutcheon volcanic series in the Barrilla Mountains, about 20 miles east-northeast of the map area. The Buck Hill and McCutcheon series, which differ considerably in thickness and lithology, represent conditions at widely separated parts of a large volcanic field. Both these volcanic sequences are older than most, if not all, of the volcanic rocks in the map area. Several graduate students, most of them under the supervision of R. K. DeFord at The University of Texas at Austin have mapped other areas in the northern Davis Mountains.

Wightman (1953) mapped a sequence of volcanic rocks about 10 miles west of the central Davis Mountains. Woodward (1954) described a similar sequence from the Killam deep test well about 15 miles west of the central Davis Mountains. The volcanic units described by Wightman and Woodward are not lithologically correlative with those in the map area, with the possible exception of some of the uppermost basalt.

Hempkins (1962), the first to do detailed mapping within the area covered by this report, worked out volcanic and intrusive rock sequences in the complex Sawtooth Mountain area. The writer has modified Hempkins' interpretations in light of additional data and mapping in a larger area.

Snyder (1962, p. 209–210) and Vogel (1942) discussed the silicified flows and tuffs in the central Davis Mountains. Snyder (1962, p. 209) reported the association of kaolin, rutile, and fine-grained white cristobalite with the silicified rocks in the southern part of the map area.

Snyder (1962, p. 205) also pointed out that consistent correlation cannot be made between optical properties and relative abundances of cations of Na, K, and Ca in feldspars of felsic rocks within the central Davis Mountains.

Harvill (1961) examined the distribution of certain elements in hydrothermally altered rocks from a road cut just east of Madera Canyon roadside park in the northern part of the map area.

Anderson (1962) established that the snowflake texture of many of the volcanic rocks resulted from devitrification.

Dr. J. L. Snyder interested the writer in the problem, originally supervised the research, and later served as an off-campus dissertation committee member. A fuller understanding of field relationships resulted from discussion with Dr. J. Hoover Mackin, the dissertation supervisor, who also gave many helpful suggestions for the manuscript.

Special credit is due Dr. S. E. Clabaugh for his help and encouragement, as well as for his valuable criticisms of the manuscript. Professor R. K. DeFord was most helpful during the preparation of the dissertation. Able assistance in the field was given by Steven V. Smith in 1961 and Carlos R. Vargas-U. in 1962. Numerous conversations with W. B. Hempkins were of great value. Dr. John P. Brand of Texas Technological College provided helpful comments in the field during the summer of 1962.

Deep appreciation is expressed to Mr. Terry Graham of the Long X ranch staff for his friendship and generosity during the field work. Thanks also are due the following residents of Jeff Davis and Culberson counties for their hospitality and cooperation: Messrs. Ralph Boone, Will and John Reynolds, C. Moore, Ben Gearheart, George Jones, Bryant Harris, Don McIvor, A. R. Eppenaur, John Fitzgerald, Dave Medley, Fritz Kahl, Dick Schwartz, Roy Largent, "Skinny" Friend, Jim Espy, and Mrs. G. Merrill.

The following fellowships, scholarships, and grants financed the cost of field work and much of the residence work at The University: Sigma Xi, RESA Grant-in-Aid of Research for the summer and fall of 1961; Walter B. Sharp Scholarship in Geology (The University of Texas) for the spring of 1962; National Science Foundation Summer Fellowship for Teaching Assistants for 1961; University Fellowship (The University of Texas) for the summer of 1962; project grant no. 893–62 of the Penrose bequest from the Geological Society of America for 1962–63.

GEOLOGIC FORMATIONS

Rocks exposed in the central Davis Mountains range in age from Cretaceous(?) to Quaternary. Metamorphosed limestone and sandstone constitute the rocks of Cretaceous(?) age. Igneous extrusive and intrusive rocks constitute the rocks of Tertiary age. Quaternary rocks include terrace gravel, alluvium, and colluvium. This report deals only with the Cretaceous(?) and Tertiary rocks.

CRETACEOUS(?) ROCKS

Marble and quartzite, metamorphosed Cretaceous(?) sedimentary rocks, crop out over an area of something less than a square mile in H. O. Canyon south of Sawtooth Mountain. The light color of the metasedimentary rocks contrasts strikingly with the surrounding igneous rocks, and it has given rise to the local name of "White Hills" for the outcrop area. Rocks from this area were first described by Osann (1896, p. 400).

Marble is by far the more abundant of the two rock types. It is light gray, locally white or light brownish gray, and very fine grained. Of the five specimens examined, one contains 2 percent and another 10 percent fine-grained, yellow, anhedral garnet(?). The others contain no calc-silicates, but a small amount of quartz is present in all three.

Hempkins collected several distorted, high-spired gastropods from the marble. They are too highly distorted for accurate identification but are thought to be aquatic forms, not necessarily marine (Hempkins, 1962, p. 30).

The marble is folded into several tight, asymmetrical anticlines and synclines which plunge gently to the east and southeast. It is in fault contact with intrusive rocks to the south. A fault along the northern border of the metasedimentary block is suggested by the greater abundance of coarsely brecciated limestone and volcanic rock in the stream gravel there than elsewhere. The irregular eastern boundary probably results from intrusion into the marble of quartz microsyenite and quartz trachyte, but no contacts are exposed.

R. K. DeFord identified the marble as probably Finlay limestone of Albian age (Hempkins, 1962, p. 31; Snyder, 1962, p. 208).

Quartz is the only essential mineral of the quartzite. Most of the grains range from 0.08 mm to 0.4 mm in diameter, but microcrystalline quartz is present in amounts up to 5 percent. Trace amounts of rounded zircon and subhedral to euhedral magnetite-ilmenite grains occur in the quartzite.

Because the quartzite crops out only in the crests of anticlines it probably pre-dates the marble. R. K. DeFord has identified the quartzite as probably Cox Sandstone of Albian age (Hempkins, 1962, p. 31).

The most likely mechanism by which the metasedimentary rocks of the White Hills attained their present position and configuration is given in the following sequence of events: Faulting was accompanied by upward movement of magma along fractures in the Cretaceous rocks. Some of the Cretaceous rocks were carried upward, folded, and slightly metamorphosed as a result of faulting and intrusion (Hempkins, 1962, p. 105–107).

TERTIARY ROCKS

The Tertiary rocks of the Davis Mountains are a small part of the Trans-Pecos alkalic igneous province, which extends westward and southeastward into Mexico.

Osann (1896, p. 428) reported the chemical analysis of a specimen of the Sawtooth Mountain microsyenite. The analysis lists 11.67% Na_2O and 6.03% K_2O, as compared with 4.0% and 4.5%, respectively, in an "average" syenite (Daly, 1933, p. 11). The Sawtooth Mountain specimen is poor in CaO and slightly deficient in Al_2O_3.

Turner and Verhoogen (1960, p. 194) stated that rocks are classed as alkalic if the ratio ($K_2O + Na_2O$) to SiO_2 or Al_2O_3 is high enough to permit formation of alkalic (commonly sodic) minerals such as feldspathoids and aegirine. Feldspathoids indicate a high proportion of alkali metal oxides with respect to silica; aegirine, aegirine-augite, and nonaluminous sodic amphiboles reflect a high proportion of alkali metal oxides with respect to alumina.

Feldspathoidal igneous rocks have been recognized in many parts of Trans-Pecos Texas. Lonsdale (1940, p. 1549 and 1564) described a number of analcime-bearing rocks in the Big Bend area to the south. Analcime occurs in igneous rocks in other areas south and southeast of the central Davis Mountains (Eifler, 1943, p. 1636; Goldich and Elms, 1949, p. 1154 and 1158; Moon, 1953, p. 189; and McAnulty, 1955, p. 561). Huffington (1943, p. 1038) reported analcime in igneous rocks of the Quitman Mountains, about 50 miles west-northwest of the central Davis Mountains.

Feldspathoids have not been recognized in any rocks from the central Davis Mountains, but flame photometer analyses which show high ratios of Na and K to Ca in feldspar phenocrysts substantiate the alkalic nature of the rocks (Snyder, 1962, p. 201–202).

Sodium-rich mafic minerals also substantiate the alkalic nature of the rocks within the central Davis Mountains. Olive-brown hornblende and riebeckite, commonly as mantles on the olive-brown hornblende, are the most abundant amphiboles. Aegirine-augite is the most common pyroxene in the intrusive rocks. It is found in the extrusive rocks but is less common than augite. Biotite is almost ubiquitous in the intrusive rocks, although commonly resorbed, and occurs in many of the volcanic rocks.

It is plain that the alkalic minerals represent a high ratio of Na_2O and K_2O to Al_2O_3 and CaO. The rocks are not deficient in silica; indeed, many contain free quartz.

EXTRUSIVE ROCKS

The extrusive rocks in the central Davis Mountains may be divided into four general types based on composition: rhyolite, latite, trachyte, and basalt.

Most of the rhyolitic strata are ignimbrites. Following Mackin (1960, p. 86), the term ignimbrite is used in this paper

> . . . for the depositional unit formed by the nuée ardente type of eruption without regard for the degree or method of lithification from level to level or from place to place.

Several kinds of evidence show that the rhyolite units are ignimbrites. They are composed largely of glass shards and crystal fragments, especially feldspars. In spite of their silicic composition, they are sheet-like in form and cover at least several hundred square miles, with two possible exceptions (*see* map and fig. 1). Common distortion or thinning of foliation layers around phenocrysts is indicative of compaction of plastic material rather than flow (Ross and Smith, 1961, p. 34).

On the other hand, the rhyolite formations locally show lineation in the foliation plane. The lineation is thought to be a result of viscous flow (Ross and Smith, 1961, p. 34), which marks these units as somewhat peculiar ignimbrites. Mackin (1960, p. 99) described similar features in the Baldhills and Hole-in-the-Wall Members of the Isom Formation of southwestern Utah. The Isom units have vesicular tops; the Davis Mountains rhyolites do not.

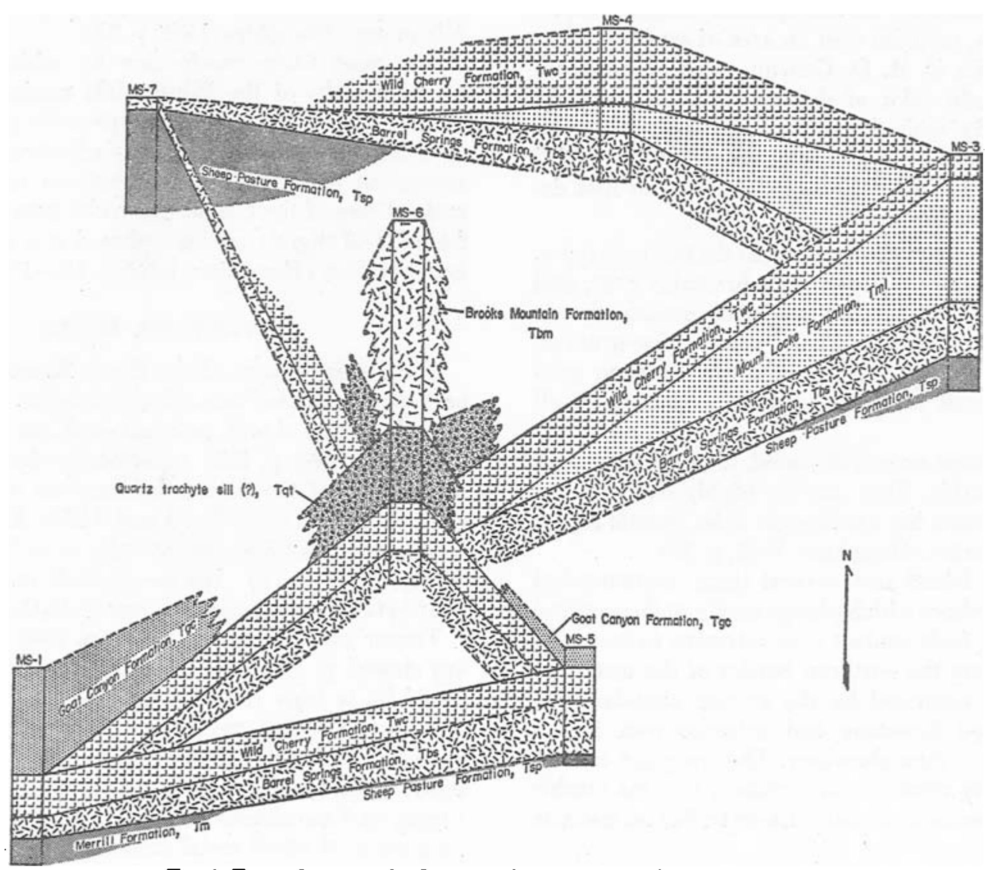

FIG. 1. Fence diagram of volcanic rocks of the central Davis Mountains.

Latite porphyry comprises three formations which are almost identical petrographically. Two of them occupy only small parts of the map area, but the third is quite extensive. The great areal extent of a unit as silicic as latite suggests that it may be an ignimbrite, but it is not as sheet-like as the rhyolites (fig. 1), nor does it exhibit any other features of ignimbrites. Similar rocks, the rhomb porphyries, are described by Oftedahl (1952) from the Oslo region of Norway. Rutten and Van Everdingen (1961) suggested that the Oslo rhomb porphyries are ignimbrites.

There are two trachyte units in the central Davis Mountains; these are more restricted in areal extent than the rhyolite and latite units (map and fig. 1).

The two basalt units are similar mineralogically, but their relative ages are not known. Basalt is the least abundant extrusive rock type in the map area.

Ignimbrites as stratigraphic units.—Zones based on degree of welding and devitrification can be recognized in the rhyolite units in the Davis Mountains but not as consistently or clearly as in the idealized situation presented by Smith (1960b, pl. 20). The zone of no welding either is not preserved, never existed as a thick or widespread deposit, or is largely covered. The only clearly defined zone of partial welding examined by the writer is outside the map area, in the vicinity of Fort Davis (Snyder, 1962, p. 199, fig. 2, locality 6, and p. 211).

Foliated black vitrophyre of the densely welded zone is common but cannot be traced persistently over any large area. The lack of continuity may be a result either of its (1) never having been continuous, (2) complete devitrification, or (3) being covered because of its high susceptibility to weathering. Mackin (1960, pp. 91–92) pointed out that the transition zone between vitrophyre and crystalline rock in the Bauers tuff of southwestern Utah is rarely exposed because of its susceptibility to weathering.

Foliated devitrified welded tuff is by far the most widespread and abundant of the four rock types resulting from welding and devitrification.

Smith (1960b) suggested that high temperature, high lithostatic load pressure, high volatile content, and high silica content tend to produce a greater zone of dense welding, with a high propensity to crystallization (devitrification). On this basis, assuming that the missing zones were never present to any great extent, individual ignimbrites of the Davis Mountains represent either one or some combination of the following: particularly thick; high temperature; highly siliceous; or especially gas-rich ignimbrites.

The non-welded portions of ignimbrites are generally non-sorted but may show lateral variation in size sorting of the particles (Smith, 1960a, pp. 821–823). The mechanisms of origin of both air-fall and water-lain tuffs should give rise to deposits which show definite vertical variations in grain size or bedding or both. No regular vertical variations in grain size have been observed among the rocks of the Davis Mountains.

Exposures of unconsolidated tuff of any kind are rare in the map area because of the rock's relatively low resistance to weathering. The abundance of tuff can be inferred from its common presence in talus and stream deposits. The nature of its vertical grain size variations and bedding characteristics cannot be determined because of the paucity of exposures.

The formal stratigraphic units include whatever non-welded tuff may be present, not because it is known to be genetically related to the other portions of the units, but because neither can it be examined adequately in hand specimen or outcrop, nor can it be traced independently for any great lateral distance. Stratification in the few exposures which can be examined suggests that most of the non-welded tuff is a product of deposition either from the air or in water.

Lower rhyolite.—The lower rhyolite was first described in the northern Davis Mountains by Rix (1951) who used the field term "T50" to designate the unit. It is the oldest volcanic unit in the area and crops out only in the northeast part. In common with most of the stratigraphic units in the central Davis Mountains, the lowest exposed part of the lower rhyolite forms near-vertical cliffs above which are gentle to moderate talus slopes.

The lower rhyolite is a pinkish-gray to brown, aphanitic, faintly foliated rhyolite. It differs petrographically from most of the other ignimbrites in the area only in its very low content of alkali feldspar phenocrysts.

The base of the lower rhyolite is not exposed.

Upper rhyolite.—The upper rhyolite was first described in the northern Davis Mountains by Rix (1951) who used the field term "T60" to designate the unit. Like the lower rhyolite, the upper rhyolite crops out only in the northeast part of the map area. It closely resembles the lower rhyolite in outcrop appearance, hand specimen, and thin section, and the two units are distinguished only on stratigraphic position. Their contact is inferred from the position of a pronounced increase in slope of the talus a few feet below the lowermost outcrops of the upper rhyolite. The two units are more readily distinguished in the northern Davis Mountains where they are separated by a non-resistant tuff unit.

The petrographic similarity of the lower and upper rhyolite units to the younger Sheep Pasture, Barrel Springs, and Wild Cherry Formations suggests that the former two are ignimbrites also. This is supported by their wide areal extents (John P. Brand, 1962, oral communication; Rix, 1951).

Sheep Pasture Formation.—The Sheep Pasture Formation is here named for Sheep Pasture Mountain in the northwest part of the map area at about 104° 12.5′ W. and 30° 43′ N. The type locality of the formation is measured upward from the base of Sheep Pasture Mountain on the south side in the west-central part of the mountain (MS 7).[2] Sheep Pasture Mountain was chosen as the type section because a greater thickness of the formation is exposed there than elsewhere.

Most of the Sheep Pasture Formation, including the lowest exposures, is grayish-purple to reddish-brown, foli-

[2] Location of the measured sections is shown on the geologic map; they are detailed in Anderson (1965).

ated, slightly porphyritic rhyolite, generally with snowflake texture. Indurated to friable, fine-grained vitric tuff locally occurs near the top of the formation.

The Sheep Pasture Formation is 510 feet thick at the type locality. The lower 495 feet is foliated, slightly porphyritic rhyolite, ranging in color from grayish purple low in the section to alternating grayish-purple and brown foliation laminae in the upper 145 feet. Above the foliated, slightly porphyritic rhyolite is 15 feet of indurated, aphanitic vitric tuff. The lower foot of vitric tuff is brownish yellow to cream colored. The rock becomes increasingly green in the upper 10 feet as a result of hydrothermal alteration. A planar structure, probably bedding, becomes increasingly prominent upward in the vitric tuff, perhaps reflecting an upward transition from the non-welded portion of an ignimbrite to a bedded, air-fall tuff.

At the type locality, the contact between the Sheep Pasture Formation and the overlying Barrel Springs Formation is concealed beneath talus.

A mile east of the Gearheart ranchhouse, which is 8 miles S. 28° W. of the type locality, the bedded, vitric-lithic tuff which forms the upper part of the Sheep Pasture Formation is 15 feet thick. Only 10 to 15 feet of the foliated, slightly porphyritic rhyolite is exposed beneath the vitric-lithic tuff.

In the Medley mine area, 11.5 miles S. 15° E. of the type locality, foliated, slightly porphyritic rhyolite is the only representative of the Sheep Pasture Formation. The same rock crops out 11.5 miles S. 35° E. of the type locality at MS 5, where it is only 24 feet thick. The contact between the Sheep Pasture Formation and the overlying Barrel Springs Formation is concealed in this general area by talus which covers 40 to 65 feet of section.

At Mount Locke, 12 miles S. 73° E. of the type locality, 165 feet of the Sheep Pasture Formation is exposed; the base is not seen. The lower 135 feet is indistinctly foliated, slightly porphyritic rhyolite, the upper 15 to 20 feet of which is brecciated. From 135 to 140 feet above the lowest exposure is a covered zone, above which is indurated to friable, fine-grained vitric tuff which is 26 feet thick. The tuff ranges in color from grayish pink at the lowest exposure to red at the top. Stratification becomes more distinct upward. The tuff is overlain by the Barrel Springs Formation. The contact is sharp and clearly defined in road cuts; elsewhere the tuff forms a gentle slope which commonly is covered by talus.

No data are available with respect to variations in original total thickness of the Sheep Pasture Formation. Its source is unknown.

Merrill Formation.—The Merrill Formation is here named for Merrill Canyon, which is crossed by State Highway 166 at about 30° 33′ N. in the map area. The type section of the formation is measured upward from the bed of Merrill Canyon on the northwest side of High Peak, 2 miles northeast of the intersection of Merrill Canyon with the highway (MS 1). Merrill Canyon was chosen as the type section because the formation is better exposed and thicker there than at other localities.

The Merrill Formation consists chiefly of hard, reddish-brown latite porphyry with translucent colorless to pale pink phenocrysts. The rock is brown to yellow brown, pitted on the weathered surface. Locally, fine to coarse-grained vitric-lithic tuff is found at the top of the formation. Low, rounded hills with hummocky surfaces are typical of the Merrill Formation. The formation is the lowest of three latite porphyry units which have characteristics more suggestive of lava flows than ignimbrites.

The upper 125 feet of the Merrill Formation is exposed at the type section; the base is covered. Localized vesicular zones in the latite porphyry, gradational to non-vesicular in all directions, are found between 75 and 90 feet from the lowest exposure, and above 118 feet. The upper 40 to 45 feet exhibits gentle contortion of the foliation. The upper 4 feet is covered; the contact with the overlying Barrel Springs Formation is determined by the uppermost occurrence of latite porphyry fragments in the covered zone.

A 5-foot thick exposure of fine to coarse-grained tuff showing graded bedding occurs at the top of the Merrill Formation in a creek bed outcrop 3⅔ miles north of the type locality.

The formation thins abruptly to the east and is not found east of a line from the east side of the White Hills to the intersection of State Highway 166 with the north-south-striking fault at 109° 13.7′ W. longitude.

Direction of movement of the lava represented by the Merrill Formation has not been determined. Zones which contain abundant vesicles also exhibit the greatest amount of contortion of planar features.

Barrel Springs Formation.—The Barrel Springs Formation is here named for the old Barrel Springs stagecoach stop, now on State Highway 166 at about 30° 32′ N. and 104° 13.9′ W. in the southwest part of the map area. The type section of the formation is measured upward from the top of the Merrill Formation on the lower slopes of the northwest side of High Peak, 2 miles northeast of the intersection of Merrill Canyon with Highway 166 (MS 1).

Four rock types are distinguished in the Barrel Springs Formation: black, foliated vitrophyre; pinkish-gray to purplish-brown, foliated, porphyritic rhyolite; non-foliated, porphyritic rhyolite; indurated to friable, fine-grained vitric tuff.

The Barrel Springs Formation is about 105 feet thick at the type locality. The contact between the underlying Merrill Formation and the Barrel Springs is covered, as is the lower 10 to 15 feet of the Barrel Springs. The nature of the rock concealed by this covered zone can be inferred from examination of the talus. The lower 9 feet of the covered zone contains black, foliated vitrophyre and non-foliated, porphyritic rhyolite. Neither of these rock types occurs in the immediately overlying part of the Barrel Springs Formation. The top 4 feet of the covered zone contains only rocks like those which crop out above.

Above the covered zone is 80 feet of foliated, porphyritic rhyolite, pinkish gray with white phenocrysts, and purplish brown on the weathered surface. Low, but pronounced, ledges are formed in the lower 15 to 25 feet of outcrop. Foliation is gently contorted but becomes less so higher in the exposed part of the formation, especially in the upper 10 to 15 feet. An 11-foot covered zone conceals the contract with the overlying Wild Cherry Formation. The contact is placed at 8 feet above the base of the covered zone, at the highest occurrence of foliated, porphyritic rhyolite like that in the Barrel Springs.

The Barrel Springs Formation is estimated to be about 250 feet thick at a locality 8½ miles N. 84° E. of the type section (MS 1) (*see* map and fig. 1). The lower contact is concealed beneath talus. The lower 10 feet above the covered zone is reddish-brown to grayish-brown, non-foliated, porphyritic rhyolite with white phenocrysts. The weathered surface is brownish red. This part of the formation is highly brecciated, showing fragments of both foliated and non-foliated porphyritic rhyolite in a matrix of non-foliated porphyritic rhyolite. This interval in the Barrel Springs forms low ledges which grade upward to the more gentle slopes of the foliated porphyritic rhyolite. This foliated rhyolite occupies about 190 feet of section and ranges from gray through white to red upward in the section. The color changes are a result of an increasing degree of alteration in the upper exposed parts of the formation. A thick covered zone conceals the contact with the Wild Cherry Formation.

The Barrel Springs Formation is at least 155 feet thick at Brooks Mountain, 4.4 miles N. 21° E. of the type section (MS 6). The base of the formation is buried under stream gravel and talus. The lower 50 feet of the exposed part is reddish-brown, foliated, porphyritic rhyolite which grades upward to 25 feet of non-foliated porphyritic rhyolite. A 40-foot covered zone forms a gentle slope over the porphyritic rhyolite; 35 feet of vitric tuff is exposed up-hill from the covered zone. The tuff ranges from pink near its base to brownish red near its top; it generally is hard but locally is friable. Outcrops are sparse, but where exposed, the tuff is laminated (bedded?), increasingly so in the higher exposures. The upper 5 feet of the formation is covered and forms gentle slopes. The upper contact is determined by the highest occurrence of fragments of vitric tuff in the covered zone.

The Barrel Springs Formation is about 265 feet thick at Mount Locke, 14.6 miles N. 63° E. of the type section (MS 3). The lower 20 to 50 feet forms steep, locally vertical, cliffs above which the slope progressively decreases. The lower contact with vitric tuff of the Sheep Pasture Formation is sharp. A 5-foot basal breccia composed of fragments of foliated and non-foliated porphyritic rhyolite up to a foot in diameter grades upward to about 150 feet of foliated porphyritic rhyolite. Foliation is increasingly contorted upward in this part of the section; both phenocrysts and matrix grains are aligned in the foliation plane. Gray lenticles from 1 mm to 6 cm thick are common between 125 and 130 feet above the base. Patches of altered vitrophyre are increasingly abundant upward between 110 and 155 feet above the base of the formation. An upward transition to brecciated, foliated, porphyritic rhyolite between 155 and 245 feet is accompanied by continued increase in abundance of altered vitrophyre to about 50 percent of the rock. Pink vitric tuff makes up the upper 15 feet of the Barrel Springs Formation above a 5-foot covered zone. The tuff ranges from almost unconsolidated to indurated and is laminated in all exposures. A green stain (nontronite?) occurs along joints within the tuff and is especially abundant near the sharp contact with latite porphyry of the overlying Mount Locke Formation.

The known thickness of the Barrel Springs Formation 12½ miles N. 35° E. of the type section is 75 feet, well over half of which is covered (MS 4). At this locality the base is not exposed and the upper contact is covered. The only rock exposed is foliated porphyritic rhyolite, but foliation becomes less pronounced in the higher exposures.

The lower 50 feet of the Barrel Springs crops out at the top of Sheep Pasture Mountain, 11 miles N. 11° E. of the type locality (MS 7). The only rock exposed is foliated porphyritic rhyolite, which ranges from reddish at the base upward to light gray and cream colored. The lower contact with altered vitric tuff of the Sheep Pasture Formation is sharply defined.

The Barrel Springs Formation gradually but constantly thins to the west within the map area. It overlies the Sheep Pasture Formation throughout most of the area, but in the southwest it overlies the Merrill Formation. The Barrel Springs Formation is overlain by the Wild Cherry Formation except in the northeastern part of the area where the Mount Locke Formation is between the two.

Mount Locke Formation.—The Mount Locke Formation is here named for Mount Locke, located at about 30° 40′ N. and 104° W. in the northeast part of the map area. The type section is measured upward from the top of the Barrel Springs Formation on the middle and upper slopes of the south side of Mount Locke (MS 3).

The formation is composed of gray latite porphyry which has translucent gray to pinkish-gray phenocrysts of plagioclase(?) which range up to 20 × 30 mm in cross section. Alkali feldspar in orthophyric, felted, and trachytic arrangements is the most abundant constituent of the matrix. The weathered surface is rough and ranges from brownish gray to reddish brown.

Steep cliffs are formed near the base of the formation, but the slope decreases upward and the surface becomes hummocky.

The Mount Locke Formation is 580 feet thick at the type section. The lower contact with vitric tuff of the Barrel Springs Formation is sharp. The lower 5 to 10 feet of the Mount Locke is intensely altered to nontronite(?), as is the underlying vitric tuff. The altered rock grades upward into fresh, gray latite porphyry. Scattered through the upper 150 feet are isolated vesicular zones, gradational in all directions into non-vesicular rock. There is a gradual increase in abundance and decrease in size of rectangular phenocrysts within the upper 40 feet. A 10-foot zone above the highest outcrop of latite porphyry is covered by talus. The top of the Mount Locke Formation is placed at the uppermost occurrence of latite porphyry fragments in the covered zone, about 5 feet above the highest outcrop.

The formation thins abruptly to the west, so that 6½ miles N. 64° W. of the type section it is only 140 feet thick (MS 4). The base is placed at a pronounced increase in slope of the talus which covers the lower 70 feet of the formation and conceals its lower contact. The exposed rock is latite porphyry with gently contorted foliation and abundant, elongated, aligned vesicles, especially near the top. The upper 10 feet of the Mount Locke is covered. A third of a mile west of this locality the Mount Locke Formation is absent. The same abrupt thinning can be seen southwest of the type section as well (map and fig. 1).

John P. Brand (1962, oral communication) reported that a rock similar, both in hand specimen and outcrop, to the Mount Locke latite porphyry is widespread northeast of the central Davis Mountains but he gave no information about its thickness.

"Eppenauer" basalt.—The "Eppenauer" basalt is informally named, because its areal extent in the map area is small; it may be widespread elsewhere. The formation is exposed on the Eppenauer ranch in the northeastern part of the map area. Outcrops are scarce; the best exposure is in a road cut on Spur 78, half a mile north of the summit of Mount Locke.

The "Eppenauer" basalt is dark brown to black, hard, aphanitic, and massive to vesicular. The matrix is mostly labradorite (An 50–55, determined by maximum extinction angles) in a sub-trachytic arrangement. The average maximum dimension of feldspar laths is about 0.1 mm. Phenocrysts generally are absent or present only in trace amounts and are labradorite, as indicated by a beta index of refraction of about 1.560. Intergranular magnetite(?) is abundant. Iddingsite has replaced olivine. Intersertal chlorite, which makes up about 15 percent of the rock, probably has replaced augite or hornblende.

Neither upper nor lower contacts of the "Eppenauer" basalt are exposed, but the total thickness probably exceeds 100 feet. Vesicular zones are scattered all through the unit, but vesicularity increases upward to a maximum of 25 percent of the rock in the upper 15 to 20 feet. The number of flows, if more than one, which make up this unit has not been determined because of the paucity of outcrops. The unit overlies the Mount Locke Formation and is below the Wild Cherry Formation.

Jones Formation.—The Jones Formation is here named for the Jones ranch, on which the type section is located (MS 2). The type section, at 30° 33.2′ N. and 104° 16.2′ W., is measured upward from the stream gravel and talus on a low rounded hill on the north side of the graded county road in Merrill Canyon. The formation is exposed only in the southwestern part of the map area.

The Jones Formation is composed of hard, black basalt, which forms low, gentle hills with abundant cobbles and boulders on the surface. Whether the formation is made up of one or several flows is not known because of the lack of outcrops.

Petrographically, basalt of the Jones Formation is much like the "Eppenauer" basalt. The rock contains colorless to light brown, intergranular augite in amounts from 4 to 18 percent. They contain up to 5 percent hornblende and chlorite after augite. Intergranular augite in the Jones Formation corresponds to the intersertal chlorite in the "Eppenauer" basalt. Olivine of the Jones Formation is altered to iddingsite and antigorite(?), but the two alteration products do not occur together. Olivine of the "Eppenauer" basalt is altered only to iddingsite.

The Jones Formation is 45 feet thick at the type locality. The base of the formation is not exposed at the type section or elsewhere. The formation is slightly foliated in its lowest exposure at the type section but becomes more massive upward. It is not overlain by other rocks anywhere within the map area.

The youngest rock upon which the Jones Formation has been emplaced is called "Wild Cherry—Barrel Springs undifferentiated." It is conceivable that the Jones Formation, like the "Eppenauer" basalt in the northeastern part of the map area, occupies a stratigraphic position below the Wild Cherry Formation and above the Barrel Springs Formation. This is not to suggest that the two basalts are necessarily remnants of the same flow, because they are widely separated geographically, and each occupies a relatively restricted area. Furthermore, there is no independent evidence of any large-scale erosion which might account for their absence between the two outcrop areas. It is possible, however, that both units were derived from the same magma chamber at approximately the same time. The weak point in this argument is that the "Eppenauer" basalt is overlain by the Wild Cherry Formation but the Jones Formation is not. Possibly the Jones Formation is the youngest igneous rock in the map area.

Wild Cherry Formation.—The Wild Cherry Formation is here named for Wild Cherry Creek, which crosses State Highway 118 about 0.8 mile west of the type section. The type section, at about 30° 42.5′ N. and 104° 07′ W., is measured upward from the top of the Mount Locke Formation to the top of the hill on the south side (MS 4).

Three rock types are distinguished in the Wild Cherry Formation: black, foliated vitrophyre; foliated, porphyritic rhyolite; and indurated to friable, fine-grained vitric tuff.

The Wild Cherry Formation is 355 feet thick at the type locality. The contact with the underlying Mount Locke Formation is covered as is the lower 40 feet of the Wild Cherry. The covered zone contains nothing but fragments of the rocks exposed higher in the section.

Above the covered zone is 140 feet of foliated, porphyritic rhyolite. It is purplish gray to brown with white phenocrysts and has a brownish-red weathered surface. It is strikingly uniform in appearance and composition through this part of the section and forms steep, but not vertical, ledges.

Up-hill from the foliated, porphyritic rhyolite 85 feet of section is covered. Fragments of breccia composed of pieces of foliated, porphyritic rhyolite in a matrix of the same material can be found as high as 25 feet above the base of the covered zone. The covered zone also contains black, foliated vitrophyre, some of which is partly devitrified, up to about 45 feet above the bottom of the covered interval.

The upper 40 feet of the covered zone contains only debris from rocks like those exposed higher in the section.

Foliated, porphyritic rhyolite, identical to that below the thick covered zone, makes up the upper 90 feet of the formation at the type section. The Wild Cherry Formation is the youngest body of rock at the type locality; therefore, no top of the formation is present.

Only 110 feet of the Wild Cherry Formation is preserved at Mount Locke, 6½ miles S. 64° E. of the type section (MS 3). The lower 5 feet of the formation is covered on Mount Locke. The rock is similar to that at the type locality, but the color is much less uniform, ranging from reddish brown near the base through purplish brown to purplish gray at the top of Mount Locke. Phenocrysts aligned parallel in the foliation plane and contorted foliation are well displayed, particularly in the upper 40 feet. The contorted foliation layers have wave lengths on the order of 20 feet and amplitudes of about 6 feet. That such linear and planar features are not observed at the type locality may be a result of the much better exposures on Mount Locke. The Wild Cherry Formation is the youngest unit on Mount Locke, as it is at the type section.

A thickness of 180 feet is assigned to the Wild Cherry Formation at a locality 9 miles S. 7° E. of the type section (MS 5). A covered zone about 100 feet thick conceals the contact with the underlying Barrel Springs Formation. The only exposed representative of the formation is foliated, porphyritic rhyolite like that on Mount Locke. Forty-eight feet of section is exposed; the middle third forms a gentle slope mostly covered by talus. The top of the formation is concealed but is picked at the uppermost occurrence of foliated, porphyritic rhyolite fragments in the talus, about 30 feet above the highest outcrop.

The Wild Cherry Formation is 220 feet thick on Brooks Mountain, 8.3 miles S. 47° W. of the type section. The lower 5 feet is covered. The contact with the underlying Barrel Springs Formation is concealed but is picked at a slight increase in slope in the talus. A 215-foot section of foliated, porphyritic rhyolite is exposed above the covered interval (MS 6). The rock is the same as that part of the formation seen on Mount Locke. Talus covers 25 feet of section and conceals the contact with an overlying quartz trachyte sill.

The Wild Cherry Formation is 195 feet thick at High Peak, 12 miles S. 35° W. of the type section. Above the lower 5 feet of the formation, which is covered, 5 feet of partly devitrified, black vitrophyre crops out. Brown to yellow-brown devitrification "balls" and lenses are abundant in the vitrophyre, and foliation is pronounced. Above the vitrophyre is 100 feet of pinkish-gray, foliated, porphyritic rhyolite which locally forms low (10± feet), steep ledges just above the vitrophyre. The talus that covers 10 feet of section above the foliated, porphyritic rhyolite contains abundant fragments of black, foliated vitrophyre, pink to pinkish-gray, slightly indurated, vitric tuff, and small amounts of breccia composed of foliated, porphyritic rhyolite fragments in a matrix of the same material. Foliated, porphyritic rhyolite, like that below the covered interval, is 55 feet thick above the covered zone. Talus covers the upper contact of the formation, which is placed at the highest occurrence of foliated, porphyritic rhyolite fragments 20 feet above the highest outcrop.

The thickness of the Wild Cherry Formation shows a marked decrease from the northernmost to the southernmost exposures, with a slight easterly component of decrease in thickness (fig. 1). Black, foliated vitrophyre which occurs well above the base of the formation in the westernmost exposures not only thins to the south and east but also is found nearer the base in the southern part of the area. In the north-central part of the area (MS 4), the vitrophyre occurs between 180 and 220 feet above the base; in the southwest it lies between 110 and 120 feet above the base (MS 1). The vitrophyre is not present in the eastern part of the area.

The presence of vitrophyre, as well as brecciated porphyritic rhyolite, in the middle part of the section suggests that the Wild Cherry Formation may represent two separate ignimbrites, at least in its western exposures. Smith (1960b, pp. 153–155 and pl. 20) pointed out that basal vitrophyre diminishes away from the source of an ignimbrite and may even disappear. So perhaps the upper ignimbrite, if such there be, has its source in the northwest or west if the vitrophyre in the middle of the formation is in fact a basal vitrophyre.

The presence of black, foliated vitrophyre at the base of the Wild Cherry Formation is established definitely only in the southwestern part of the map area (MS 1). This distribution of vitrophyre suggests that the main source of the Wild Cherry Formation, or the lower ignimbrite in it, if two exist, is somewhere to the southwest of the map area (Smith, 1960b, pp. 153–155 and pl. 20). If the main source is to the southwest, then the possibility that the intermediate vitrophyre represents the base of a second ignimbrite in the western reaches of the formation is strengthened but certainly not proven.

"Wild Cherry—Barrel Springs undifferentiated".—Throughout most of the map area the Wild Cherry and Barrel Springs Formations can be distinguished in one of two ways: (1) The Mount Locke Formation occupies an interval between the two, and (2) either non-welded tuff occurs at the top of the Barrel Springs Formation, or black, foliated vitrophyre occurs at the base of the Wild Cherry Formation. In the west-south-central part of the map area, these lithologic changes cannot be used as criteria. Rocks in this area are no different from those elsewhere in the two formations, but neither contacts nor zones can be traced far enough to distinguish the formations from each other. Because of the greater depth of erosion to the west, probably much of the "Wild Cherry—Barrel Springs undifferentiated" is low in the section and would be assigned to the Barrel Springs Formation if contacts could be extended. On the east, the contact is relatively easy to locate; westward, non-foliated porphyritic rhyolite and non-welded tuff become increasingly abundant at the top of the Barrel Springs and at the base of the Wild Cherry Formation until, finally, they merge imperceptibly and the contact can be traced no farther.

The lack of distinction between the two formations may be explained by assuming that the undifferentiated part is at or near the distal margins of both formations, or at least the limit of the Wild Cherry Formation.

Medley Formation.—The Medley Formation is here named for the Medley ranch, which bears the type section. The type locality, at 30° 33.6′ N. and 104° 09.9′ W., is high on the southeast side of the same hill as the Medley kaolinite mine. The type section is measured upward from the top of the Wild Cherry Formation.

The only rock type in the Medley Formation is latite porphyry similar, if not identical, to that of the Mount Locke Formation. It is vesicular at all known localities, with the abundance of vesicles slightly increasing upward.

Nowhere has the total thickness of the Medley Formation been determined. Although its lower contact commonly is exposed, the upper contact invariably is covered by thick talus from the overlying Goat Canyon Formation. The thickest exposure of the Medley Formation is 22 feet at the type locality. It is completely covered by talus from the overlying Goat Canyon Formation in many places near the Medley mine, and its presence can be established only by careful examination of the material making up the talus. The areal extent of the Medley Formation is only about 0.25 square mile.

The nature and origin of the Medley Formation are uncertain. The present areal extent of the formation might indicate that it is of local origin, but no concrete evidence sheds light on how much erosion took place this high in the section before eruption of younger rocks. The vesicularity of the rock strongly suggests that it is extrusive, but vesiculation also can occur in intrusive rocks at shallow depths (Williams et al., 1955, p. 23).

The Medley Formation, which directly overlies the Wild Cherry Formation in an area of intense silicification of both the Wild Cherry and Barrel Springs Formations, shows no effects of alteration other than from surface weathering. Neither are any younger rocks silicified. It is therefore probable that the Medley Formation lies on an erosion surface, rather than its being fresh because of selective silicification of the Wild Cherry Formation.

Goat Canyon Formation.—The Goat Canyon Formation is here named for Goat Canyon, a tributary of Merrill Canyon in the southwest part of the map area. The type section is measured upward from the top of the Wild Cherry Formation to the top of the west side of High Peak, at 30° 33.8′ N. and 104° 15′ W. (MS 1).

The Goat Canyon Formation is made up of one or more lava flows of hard, gray to greenish-gray, porphyritic-aphanitic trachyte with a trachytic matrix and white alkali feldspar phenocrysts. The rock has a grayish-white to yellow-brown, platy weathered surface and, as at the type locality, forms high steep cliffs.

The Goat Canyon Formation is 515 feet thick at the type section (MS 1). The lower 130 feet is covered; the lower contact is placed at the uppermost occurrence of fragments of foliated, porphyritic rhyolite of the underlying Wild Cherry Formation in the talus. Greenish-gray, porphyritic trachyte is moderately well exposed throughout the remaining 385 feet of section. As nothing crops out above the Goat Canyon Formation at the type section or elsewhere, the total original thickness is not known.

The Goat Canyon Formation is only 100 feet thick 8.1 miles N. 84° E. of the type section (MS 5). There the lower 45 feet of the section is covered; the lower contact is placed at the highest occurrence of fragments of foliated, porphyritic rhyolite in the talus.

Except where the Medley Formation is present, the Goat Canyon Formation directly overlies the Wild Cherry Formation. The Wild Cherry Formation is overlain at some places (e.g., MS 6) by the quartz trachyte sill. Although the Goat Canyon Formation and the quartz trachyte sill are nowhere in contact, they are in close proximity near the heads of Goat and Merrill Canyons.

Brooks Mountain Formation.—The Brooks Mountain Formation is here named for Brooks Mountain, at 30° 37.5′ N. and 104° 13.8′ W. in the west-central part of the map area. The type section is measured upward from the top of the quartz trachyte sill on the upper slopes of the west side of Brooks Mountain (MS 6).

The formation is composed of brown, aphanitic to fine-grained, porphyritic trachyte with an orthophyric matrix and colorless to gray alkali feldspar phenocrysts. The rock has a grayish-brown weathered surface and forms steep, locally vertical, cliffs. Weathering and erosion of the Brooks Mountain Formation result in prominent and numerous talus piles. Similar deposits commonly develop on the Goat Canyon Formation also. Close examination in the field is, therefore, essential to distinguish which of the units is the parent of a given talus deposit.

The Brooks Mountain Formation is found only on and near Brooks Mountain, where it is 985 feet thick and overlies the quartz trachyte sill. Their mutual contact is placed at a rather abrupt increase in slope in a covered zone 20 feet below the lowest outcrop of the Brooks Mountain Formation (MS 6). Upward from the covered zone there is 315 feet of porphyritic trachyte. The only lithologic distinction between this and higher parts of the formation is that the lower rock is aphanitic to very fine grained, whereas all that above is fine grained. Above the lowest trachyte, there are 25 feet of cover, 210 feet of porphyritic trachyte, 75 feet of cover, and 145 feet of porphyritic trachyte. The three upper exposures look the same in both hand specimen and thin section. All exposures are steep, near-vertical cliffs, whereas the covered zones are moderately steep slopes.

No contacts are recognized within the exposed parts of the formation. Assuming that each covered zone conceals a contact between adjacent flows, one may postulate that the Brooks Mountain Formation is composed of four separate flows. Obviously, the validity of such a conclusion is open to question, not only because the covered zones may not represent contacts but also because the cover could conceal entire flows. All that safely can be said is that the Brooks Mountain Formation is composed of porphyritic trachyte, the lower third of which is aphanitic to very fine grained, and the rest of which is fine grained.

The orthophyric texture, small areal extent, and great thickness support speculation that the Brooks Mountain Formation is intrusive rather than extrusive. Contact relations cannot be used to establish the mode of emplacement of the formation, because its base is covered and overlying rocks are lacking. The formation is tentatively classed as extrusive because of its fine-grained texture and its close mineralogic affinity to the Goat Canyon Formation, but there is no clear evidence that it is not intrusive.

"Rhyolite-trachyte undifferentiated".—Several isolated exposures of various rock types, referred to herein as "rhyolite-trachyte undifferentiated," are found in the vicinity of Sawtooth Mountain, particularly north and east of it. None of the rocks have been assigned by the writer to any of the formations in the map area. Hempkins (1962) tried to arrange these rocks in stratigraphic sequence and to relate them to some of those immediately surrounding, but he regarded his stratigraphic sequence as open to question (W. B. Hempkins, 1962, oral communication).

The area in question has intrusive rocks abundant in it and around its borders. This setting suggests that the rocks referred to as "rhyolite-trachyte undifferentiated" represent xenoliths in an intrusion (quartz microsyenite?).

Quartz microsyenite is also abundant in the southeast corner of the map area. Nothing, however, that might be considered a xenolith is found in this area, except at one locality. A tiny outcrop of greenish-gray, porphyritic trachyte like that in the Goat Canyon Formation is exposed in a creek bed at an elevation between 650 and 700 feet lower than the nearest outcrop of this rock and about half a mile northeast at MS 5. This creek-bed exposure may be a large buried boulder, a xenolith, or part of a downthrown fault block.

Correlation and age.—Most of the volcanic rocks of the central Davis Mountains are relatively high in the Tertiary section of the Davis Mountains, and none are in depositional contact with Cretaceous sedimentary rocks.

The lower rhyolite, which is the lowermost volcanic rock in the map area, was previously designated "T50" by Rix (1951). John P. Brand (1962, oral communication) traced the unit from the northern Davis Mountains to the northeast extremity of the map area. Colton (1957, pl. 4) correlated the "T50" with the following: the Moon trachyte in the Zopilote Hills (Hay-Roe, 1958); the plagioclase trachyte and red trachyte members of the Fairbury Formation, the Blanquito Agglomerate, and the upper tuff member of the Blanquito at Chispa Mountain (Hay-Roe, 1958); most of the upper part of the Seven Springs Formation in the Barrilla Mountains (Eifler, 1951); the upper part, or perhaps all, of the Duff Tuff in the Cathedral Mountain area (McAnulty, 1955) and in the Tascotal Mesa area north of Big Bend National Park (Erickson, 1953); and the Capote Mountain Tuff in the Sierra Vieja. The Capote Mountain Tuff ranges in age from latest Duchesnean to early Chadronian (early Oligocene) based on the most recent information available (John A. Wilson, 1964, personal communication).

The upper rhyolite, which overlies the lower rhyolite, was previously designated "T60" by Rix (1951). Colton (1957, pl. 4) correlated the "T60" with the following: the Means sanidine trachyte at Chispa Mountain (Hay-Roe, 1958); the uppermost part of the Seven Springs Formation in the Barrilla Mountains (Eifler, 1951); the Mitchell Mesa ignimbrite and, possibly, the Tascotal Formation in the Cathedral Mountain area (McAnulty, 1955) and in the Tascotal Mesa area (Erickson, 1953); and the Brite ignimbrite in the Sierra Vieja. The Brite ignimbrite is Chadronian (early Oligocene) in age based on the most recent information available (John A. Wilson, 1964, personal communication).

The Sheep Pasture Formation of the central Davis Mountains may be correlative with the Tascotal Formation of the southern Davis Mountains, but additional mapping is necessary to properly evaluate this possibility.

The Jones Formation is younger than at least part of the undifferentiated Wild Cherry—Barrel Springs rocks. A minimum relative age of the Jones Formation has not been established because no other stratigraphic units overlie it within the map area. The stratigraphic position of the Jones Formation, as well as its geographic position in the extreme southwestern part of the map area, suggests that it may be correlative with one of the basalt units, possibly the "T18", penetrated by the Killam-Means No. 1 deep test well located about 15 miles west of the map area (Woodward, 1954) and with the "T90" basalt on the surface 5 to 10 miles west of the map area (Wightman, 1953).

No other volcanic rocks in the central Davis Mountains can be correlated stratigraphically with any in surrounding areas.

A maximum age of Oligocene is indicated for the central Davis Mountains units, most of which are higher in the section than those which have yielded late Eocene and Oligocene fossils. There is no evidence of long periods of erosion between emplacements of the volcanic units. Assuming that this same condition is true between the map area and the surrounding areas which have yielded fossils, an Oligocene age is not unreasonable for the rocks of the central Davis Mountains. These intervening areas have not been mapped, so that this line of reasoning is somewhat tenuous; thus, an age of Oligocene (?) is assigned to the volcanic rocks of the central part of the Davis Mountains.

INTRUSIVE ROCKS

Intrusive rocks in the central Davis Mountains are of several types: quartz microsyenite, quartz trachyte, trachyte, latite, chlorite latite, and trachyandesite. They occur as sills, small stocks, and dikes.

Quartz microsyenite.—Quartz microsyenite is the most widespread of the intrusive rocks. It occurs as small stocks, sills, and a few dikes. While some variations exist among these occurrences, they exhibit such great similarity that they are here referred to, collectively, as quartz microsyenite; they probably formed during one period of intrusion.

The quartz microsyenite which forms Sawtooth Mountain is probably a shallow sill or a flow, the maximum thickness of which is at least 1,000 feet (cross section C-C′). The areal extent is about 1¾ square miles. The roof of this igneous body has been removed and the floor is not exposed. A pronounced planar flow structure strikes N. 40° to 60° W. and gently dips to the south and contains well aligned feldspar phenocrysts which plunge in the direction of dip of the foliation. The foliation is most pronounced in the lower 200 feet of the body. The most prominent set of joints is near vertical; from the northwest part of Sawtooth Mountain to the southeast part, the strike of the joints changes regularly from N. 30° E. to N. 80° E. The flow structure and the radial joint pattern suggest that the magma moved generally from the southwest to the northeast, expanding along the strike of the movement "front."

The most abundant constituent of this rock type is alkali feldspar, both in the matrix and as phenocrysts. The phenocrysts are zoned such that the cores are commonly perthitic; the rims are clear, untwinned feldspar. Quartz ranges from 0 to 15 percent but is present in small quantities in most specimens. Mafic minerals, present in all specimens, are either biotite, aegirine-augite, or olive-brown hornblende which grades into riebeckite. Apatite is generally present in minor amounts. Zircon and chlorite are present in many specimens but at most in only minor amounts.

The quartz microsyenite most commonly is fine grained but ranges from aphanitic to medium grained.

Mineralogic and textural distinctions from place to place are not sharp nor is there any apparent pattern of variations of these parameters.

An extreme in grain size of quartz microsyenite is reached in some parts of the area between 1 and 3 miles southeast of Sawtooth Mountain and at the western extremity of the north end of Sawtooth Mountain. The grain size averages up to 3.5 × 8.0 mm. The texture is hypidiomorphic granular. Associated with the coarse-grained phase is a much finer-grained phase. In thin section, these phases are found to be essentially the same except for the difference in grain size. Sharp contacts between the coarse and fine phases are exposed in a road cut at the western extremity of the north end of Sawtooth Mountain near the entrance to Moore's ranchhouse. A study of the thin sections suggests that the fine-grained material represents the late-stage liquid that was interstitial in the already crystallized coarse-grained material. The late-stage liquid probably filled fractures which developed as crystallization drew to a close.

Quartz microsyenite exposed at Bloys Campground, on State Highway 166 in the south-central part of the map area, deviates considerably from the general description. The rock is yellow, whereas all other quartz microsyenite outcrops are pinkish to grayish pink. Limonite, which may have replaced pyrite, causes the rock to be yellow. Only about 10 percent of the feldspar occurs as phenocrysts in this exposure. Trace amounts of secondary(?) chlorite are present. This rock probably has been altered by deuteric (or hydrothermal?) processes to which other parts of the quartz microsyenite have not been subjected.

Quartz trachyte.—The quartz trachyte is widespread in the west-central part of the area where it is both discordant and concordant. It is discussed by Hempkins (1962, pp. 32–33 and 62–64) under the headings of "Ta Trachyte" and "Gearhardt Ranch stock." Hempkins considered the Ta Trachyte a lava flow and the Gearhardt Ranch stock as the intrusive source of the Ta Trachyte.

The quartz trachyte body is discordant in the area immediately south of the east side of the White Hills where it transects both the Barrel Springs and Wild Cherry Formations (cross section B-B′). Elsewhere, it is concordant.

In those areas where the quartz trachyte is concordant, no contacts are exposed so that its nature as a sill versus a lava flow cannot be tested by contact relations. That at least one of the concordant parts of this body of rock is a sill is indicated by the following evidence: Quartz trachyte concordantly underlies the Sheep Pasture Formation in an area about 4 miles northwest of the area of discordance, with practically continuous exposure between the two areas. Quartz trachyte concordantly overlies the Wild Cherry Formation in an area about 1 mile south-southeast of the area of discordance, again with practically continuous surface exposure between the two areas (cross section B-B′). As previously stated, no contacts are exposed, but because the same body of rock concordantly occupies two distinct stratigraphic positions, the stratigraphically lower part, northwest of the area of discordance, is certainly a sill. The quartz trachyte in the higher stratigraphic position, south-southeast of the area of discordance, could be a lava flow but is discussed as a sill because the northwestern part of the same body of rock is definitely a sill.

The quartz trachyte commonly contains between 5 and 30 percent alkali feldspar phenocrysts. Quartz content ranges from 0 to 12 percent. Small amounts of biotite, aegirine-augite, and olive-brown to blue-green amphibole are common constituents. The dominant mineral of the matrix is alkali feldspar, which ranges from 45 to 83 percent of the rock.

The most distinctive petrographic feature of the quartz trachyte is its high magnetite-ilmenite content. Although other rocks in the map area locally contain as much, in some instances more, magnetite-ilmenite, this unit has a consistently high magnetite-ilmenite content, 5 to 10 percent in almost all specimens.

Texturally, the quartz trachyte is generally porphyritic and orthophyric to sub-trachytic; most specimens examined are orthophyric. The mafic minerals and magnetite-ilmenite are intergranular. Quartz occurs interstitially to the feldspar in the matrix. A gradual, but distinct, decrease in average grain size from 0.1 × 0.07 mm to 0.03 × 0.005 mm away from the vicinity of the White Hills is the only regular variation that is seen.

Latite and trachyandesite.—Latite and trachyandesite are recognized only on Mount Livermore and are discussed together because of their lithologic similarity. They are distinguished (1) by the much greater abundance of iron-oxide "dust" (hematite and limonite) in the latite than in the trachyandesite, and (2) by their relative proportions of alkali feldspar phenocrysts, 10% in latite and 25% in trachyandesite. Trachyandesite comprises most of the highest part of Mount Livermore, including the summit.

The latite contains about 10 percent alkali feldspar phenocrysts. The matrix of the rock is largely obscured in thin section by abundant iron-oxide "dust," which gives the rock a brick-red color in hand specimen. The most abundant constituent of the matrix is feldspar in a seriate arrangement with an average size of 0.15 × 0.20 mm. Most grains are euhedral and very slightly zoned. In addition, the rock contains about 1 percent each of chlorite and magnetite-ilmenite. Chlorite may have replaced biotite, but the minute grain size makes this difficult to determine.

Trachyandesite contains approximately 25 percent alkali feldspar phenocrysts which are optically identical to those of the latite.

Feldspar in the matrix of the trachyandesite is divided into (1) plagioclase (An?) and (2) alkali feldspar, based solely on twinning; (1) polysynthetic twinning and (2) crossed and Carlsbad twinning, respectively. No data are available on the Na:K:Ca ratios of any of the matrix feldspar.

Quartz makes up about 1 percent of the trachyandesite and is interstitial to the feldspar of the matrix. Partially resorbed grains of augite comprise 2 percent of the rock. A slight trace of olive-brown to olive-green hornblende(?) occurs as minute, disseminated grains. Trace amounts of biotite are present as very narrow mantles on magnetite-ilmenite, which makes up 4 percent of the rock. The mafic minerals and magnetite-ilmenite are mostly intergranular, but some grains occur as small anhedral inclusions in feldspar phenocrysts.

Trachyte dikes.—Trachyte occurs as dikes in the northern west-central part of the map area to the southwest and north of Whitetail Mountain and west of McDaniel Mountain in the north-central part of the area. The dikes southwest of Whitetail Mountain are discussed by Hempkins (1962, p. 66) under the heading "Rocks associated with Whitetail vent(?)."

The trachyte dikes contain 5 to 7 percent alkali feldspar phenocrysts. The matrix is alkali feldspar with an orthophyric to allotriomorphic-granular texture. This matrix feldspar shows a bimodal grain size distribution. About 70 percent of the matrix feldspar averages 0.04 mm diameter. The coarser material, with an average size of 0.08 mm diameter, is found in lenses and blebs in the finer material. Anhedral magnetite-ilmenite, about 2 percent of the rock, is more or less uniformly distributed. Faintly zoned aegirine-augite constitutes 1 percent of the rock. Quartz, in trace amounts, is interstitial. A slight trace of subhedral to euhedral apatite is present.

Chlorite latite.—Chlorite latite is found in three general areas. (1) The largest is a small stock or plug located southwest of Whitetail Mountain at 30° 40′ N. and 104° 12′ W. (2) Another occurrence is in H. O. Canyon between 1 and 1½ miles southwest and south of the first. Several irregularly shaped outcrops are more or less aligned in this area. Their alignment and petrographic similarity to the other chlorite latite occurrences suggest that they are dikes in the quartz microsyenite. (3) The third occurrence of chlorite latite is a northwest-striking dike located about 3 miles south-southeast of the first. This dike is about 4 feet across at its widest point, and a little over 100 feet of its length is exposed. It pinches out to the southeast and is covered by talus to the northwest. Its size is exaggerated on the geologic map.

The chlorite latite contains alkali feldspar phenocrysts up to 20 mm long but with an average size of 2.0 × 5.0 mm. The matrix is mostly orthophyric and seriate alkali feldspar with an average grain size of 0.10 × 0.25 mm. Chlorite, up to 8 percent of the rock, occurs as intersertal material, as large blebs up to 1.0 mm diameter within feldspar phenocrysts, and as small blebs up to 0.2 mm diameter in the matrix. Magnetite-ilmenite is mostly very fine grained and intergranular, but some occurs as rims on chlorite.

Several regular variations can be discerned from the northernmost to the central to the southernmost occurrence of chlorite latite: the amount of alkali feldspar phenocrysts decreases from 40 to 35 to 17 percent; the amount of alkali feldspar in the matrix increases from 45 to 57 to 71 percent; and the amount of chlorite is 8 percent in the north and 3 percent in the other two localities. The amount of magnetite-ilmenite remains practically constant.

These trends suggest that progressively later stages of liquid fractionation are represented by chlorite latite dikes to the south where chlorite, representing the mafic constituents of the magma, is least abundant. Crystallization after emplacement proceeded for a longer period in the north as shown by the more abundant feldspar phenocrysts there and the progressively more abundant fine-grained matrix feldspar to the south. It is likely that this longer period of crystallization would occur in and near the magma chamber, the source of heat, than away from it. Magnetite-ilmenite crystallization probably reached completion before the differentiation already discussed, and before emplacement of the three chlorite latite dikes, as evidenced by both the uniform distribution from place to place and the intergranular occurrence of the magnetite-ilmenite. Thus, a picture is developed of a magma chamber in the north, in which magnetite-ilmenite crystallized, after which a relatively early stage liquid fraction was intruded near the magma chamber and a later stage liquid fraction was intruded as dikes to the south.

Breccia (vent agglomerate ?).—Breccia crops out in the topographically lowest part of the "Whitetail vent (?) area" (Hempkins, 1962, p. 66–69) southwest of Whitetail Mountain at about 30° 40′ N. and 104° 12′ W. The breccia is composed of volcanic rock fragments up to 3 cm in diameter in a syenitic matrix. Individual outcrops are only a few feet across. Chlorite latite is found near and on all sides of the few outcrops, but no contacts are exposed. The breccia may be a vent agglomerate, but this has not been established because of inadequate exposures.

Although the breccia is highly variable in composition, the following serves as a general analysis: 70 percent lithic fragments, mostly devitrified glassy rocks with some trachyte similar to the Goat Canyon Formation; 23 percent quartz-feldspar matrix, extremely fine grained, possibly devitrified or secondary material; 5 percent kaolinized feldspar fragments with very fine crossed twinning; 2 percent magnetite-ilmenite; trace amounts of hornblende, aegirine-augite, and biotite.

PRODUCTS OF HYDROTHERMAL ALTERATION

Silicified rocks.—The suffix (si) is appended to some of the symbols for certain rock units at several places on the geologic map. Use of the suffix indicates that the silicified rock can be traced laterally into its unaltered equivalent with a relatively high degree of confidence. Where there is doubt as to which formation has been altered, the symbol Tsi is used. Many of the localities where the (si) suffix is used are as highly silicified as those where the symbol Tsi is used.

Silicification has affected both welded and non-welded tuff, especially the latter. Both lateral and vertical transitions from unaltered to completely silicified rock can be seen near the Medley mine which is at lat. 30° 33.3′ N., long. 104° 10′ W. Snyder (1962, p. 209) pointed out that in some outcrops, contacts between the "chert" and fresh "flow-rock" are well defined. A sharp contact is present where the altered material is unconformably, but concordantly, overlain by the unaltered Medley Formation, which establishes the time of silicification as prior to extrusion of the Medley Formation.

The most highly altered material ranges from a hard, chert-like rock to a relatively soft, granular rock rich in kaolinite and cristobalite. The chert-like portion is about 94 percent microcrystalline quartz, 2 percent coarse quartz in irregular patches, and 4 percent opaque material (leucoxene?) which is yellow to yellowish white in reflected light. One thin section of the rock shows a faint banded appearance in reflected light. Whether this "banding" is a remnant of original foliation or has been produced during alteration has not been determined.

Part of the silicified rock at the Medley mine locality is a fault breccia, the fragments of which are chert-like. What might be called "ghosts" of shards are faintly discernible in fragments in the breccia. The matrix of the breccia is mostly radial microcrystalline quartz and coarsely crystalline quartz.

Silicified rock crops out on both sides of State Highway 166 at and near the Barrel Springs stage marker at about lat. 30° 31.5′ N., long. 104° 14′ W. The most abundant constituent, 80 percent of the rock, is quartz in grains up to 0.5 mm diameter, with an average grain size of 0.2×0.3 mm. Most of the grains have sutured boundaries. Microcrystalline quartz is interstitial to the coarser quartz grains. Much, but not all, of the material at this locality is coarse breccia, but all is hard and resistant like chert. The breccia and the roughly linear outcrop pattern at this locality suggest faulting. Alluvial cover and poor exposures of the surrounding rocks make determination of the amount of displacement unobtainable.

Snyder (1962, p. 209) suggested that the silicified rock at the Barrel Springs locality may be part of the Cox(?) sandstone which crops out farther north at the White Hills. The composition and grain size lend a measure of support to this idea. On the other hand, there is a certain amount of similarity between the texture of the silicified rock, as seen in thin section, and some of the devitrified volcanic rocks. This suggests that the silicified rock may be altered volcanic rock. Snyder (1962, p. 209) also speculated that these rocks may be xenoliths brought from below and subsequently silicified. This hypothesis must be considered, because no other identical rock has been found in the map area.

A striking, nearly circular outcrop of silicified rock about half a mile in diameter is located at lat. 30° 33.2′ N., long. 104° 14.5′ W. Snyder (1962, p. 209) believed it likely that hydrothermal solutions traveled along a cylindrical or conical fracture and silicified the surrounding rocks. He also was the first to recognize silicified pebble conglomerate of probable sedimentary origin in the eastern part of the ring. Lamination in the pebbles strongly suggests the foliation commonly present in welded tuff, which is abundant in the area. Some pebbles have a more "bedded" appearance; these may represent pebbles derived from water-lain or air-fall tuff. It is, thus, believed that the pebble conglomerate is derived from a local source.

Linear bodies of silicified rock extend into relatively unaltered volcanic rocks in the southeast part of the map area at lat. 30° 31.6′ N., long. 104° 08′ W. The relations suggest that hydrothermal solutions were derived from the quartz microsyenite magma and travelled away from it along fractures. Silicified rocks also are intimately associated with a prominent north-south fault which passes about one-third mile east of the "ring dike" in the southwest part of the map area. A number of outcrops, many of which are too small to be mapped individually, occur along this fault. Silicified rocks are associated with fractures at two of the three localities previously discussed. At the third locality, at and near the Medley mine, the body of silicified rock is more or less horizontal and tabular in shape, conformable with volcanic rocks above and below. Furthermore, it grades laterally into unaltered rock. It is thus hypothesized that the alteration is a result of hydrothermal solutions travelling outward along fractures from the quartz microsyenite magma and spreading laterally where sufficient permeability was encountered.

Silicification postdates emplacement of the Wild Cherry Formation, which is highly altered locally, and predates emplacement of the Goat Canyon and Medley Formations, which are unaffected.

Silicified rock at lat. 30° 33.2′ N., long. 104° 14.5′ W. (the "ring dike") is cut by a northwest-striking fault, downthrown to the west, with an undetermined, though probably small, amount of displacement. A little more than a mile to the southeast, this same fault is cut by a north-south-striking fault along which the rocks are silicified. The obvious inference to be drawn is that silicification and faulting overlapped in time.

Clay mineralized rocks.—Harvill (1961) determined which of certain elements were left behind, which removed, and which added during alteration of rocks in a road cut on State Highway 118 at lat. 30° 41.7′ N., long. 104° 05.6′ W. He concluded (Harvill, 1961, p. 39):

> Acidic hydrothermal solutions between 100°C and 300°C altered two different rocks, forming two different clay minerals. The coarse trachyte porphyry, which contained more MgO, Fe_2O_3, FeO, and Na_2O, yielded nontronite; the fine trachyte, which contained less, yielded kaolinite. In both rocks Na and K were removed, while H_2O was added. The alteration of the coarse trachyte porphyry removed Al and left behind Mg and Fe; the alteration of the fine trachyte removed Mg and Fe and left behind Al. The altering solution moved up along several channels through rocks, which may be mineralized at depth.

The coarse trachyte porphyry to which Harvill referred is part of the Mount Locke Formation, and the fine trachyte is the Barrel Springs Formation.

Nontronite is more conspicuous than kaolinite because rocks altered to nontronite have a bright green color. They are locally called "poison green rock." Probably nontronite is more abundant than kaolinite.

Several faults transect the area studied by Harvill (1961), and he suggested that the altering solutions travelled along these faults. At most other localities where similarly altered rocks crop out, faults are not evident and the altered rocks are at or near the stratigraphic contact between adjacent volcanic rock units. Such a contact is present between the Mount Locke and Barrel Springs Formations in the map area. Altered rocks along this stratigraphic contact are well exposed in a road cut on Mount Locke at lat. 30° 39.6′ N., long. 104° 01.3′ W. Green alteration (nontronite) extends upward from the contact for a distance of about 4 to 5 feet into the Mount Locke Formation and downward into the tuff of the Barrel Springs Formation for about 2 feet. Similar relations occur at other localities, but this is by far the best exposed. The altering solutions apparently moved not only along faults but also along stratigraphic contacts.

STRUCTURE

Volcanic rocks of the central Davis Mountains, as well as those farther north (Zabriskie, 1951, p. 30), generally dip 3° to 5° in a southwesterly direction. In Ryan Flat, about 10 miles west of the central Davis Mountains, near the town of Valentine, the Killam deep test well passed through 568 feet of alluvium before entering volcanic rocks (Woodward, 1954). Hempkins (1962, pp. 112–115) suggested that these rocks are a downfaulted part of the Davis Mountains sequence of volcanic rocks. He cited seismic evidence which suggests that the western boundary of the Davis Mountains is marked by a fault zone and that Ryan Flat is a graben or half-graben.

Baker and Bowman (1917) thought that the alignment of Sawtooth Mountain, Mount Livermore, and Blue Mountain (east of the map area) marks a gentle anticline, the core of which is a syenite stock. Snyder (1962, p. 199) pointed out that Blue Mountain is composed of gently dipping volcanic rocks rather than syenite. Quartz microsyenite, which crops out in the southeast corner of the map area just west of Blue Mountain, is more nearly in line with Sawtooth Mountain and Mount Livermore than is Blue Mountain. The alignment parallels many of the major structural features in Trans-Pecos Texas (Baker, 1935, p. 209). Locally, reversals of the general southwesterly dip can be recognized, but there is no single, well-defined anticline.

STRUCTURE OF VOLCANIC ROCKS

Most of the faults which cut volcanic rocks are vertical, or nearly so, as evidenced by the lack of bending of their surface traces with changes in topography. One distinct exception is located about 2 miles north-northeast of the Medley ranch headquarters, about one-half mile west of Medley's White Mountain. This fault, which dips 18° to the southwest, is probably only a minor branch of the steeply dipping fault with which it merges to the west. Both faults are downthrown to the west.

Maximum vertical displacement of most faults ranges from 25 to 75 feet. The greatest demonstrated vertical displacement is about 150 feet, both on the north-south-striking fault which crosses State Highway 166 on the south side of the area at 104° 13.7′ W., and near the intersection of two generally northwest-striking faults at the northeast end of the syncline which is located about 2¼ miles southwest of the benchmark on Mount Livermore.

The north-south fault which crosses Highway 166 at 104° 13.7′ W. is traceable for over 7 miles to the north and an undetermined distance to the south. The attitude of the fault ranges from vertical to steeply dipping to the east. Location of the fault trace is facilitated by the intermittent, but common, occurrence of silicified rock along its strike. Vertical displacement along the fault is small in the vicinity of Merrill and Goat Canyons. The fault is covered by alluvium from immediately east of High Peak to north of Goat Canyon. South of the alluvial area, the fault reaches its maximum displacement of about 150 feet, upthrown to the west. North of the alluvial area it is upthrown to the east. It is mapped as one fault because (1) both the northern and southern parts are roughly in line; (2) both parts of the fault have abundant silicified rocks along them; and (3) vertical displacement regularly increases for about 2 miles in both directions away from the covered area near the juncture of Goat and Merrill Canyons. Nearby shallow intrusions west of the fault in the south, where silicified rocks are especially abundant, and east of the fault in the north could account for the observed displacements. There is no conclusive evidence for a nearby intrusion east of the fault in the north, but it is not an unreasonable possibility.

In the area west and north of Mount Locke, faults are probably more abundant than shown on the geologic map. The great thickness of the Mount Locke Formation, coupled with its uniform lithology, make detection of minor faults extremely difficult.

Small folds have been produced at several localities by drag along faults, but at least one syncline was probably produced by an intrusion. A sinuous, broad syncline, with a gentle plunge ranging from west to south, is located in the southern part of the map area about half-way between High Peak and Medley's White Mountain. The dips of volcanic strata on the flanks of the southernmost part of this syncline could be results of drag between faults. The northern part of the syncline, where it trends generally east-west, cannot be a result of drag, because there are no nearby faults which have the correct orientations to produce such drag. It is probable that a shallow intrusion south and east of the synclinal axis has deformed the overlying volcanic rocks. A shallow intrusion is far from an unreasonable feature in this area, and certainly it could have produced the structure.

The most prominent faults in the southwestern, north-central, and northeastern parts of the map area are those which strike generally northwest. This orientation is in agreement with the regional trend. North and northeast of the central Davis Mountains, by far the most common strike of normal faults is northwest (John P. Brand, 1962, oral communication). A zone through the center of the map area, from the southeast, through the central part of the area around Mount Livermore, on through the Sawtooth Mountain area, but particularly in the southeast and central parts, is characterized by abundant faults in no apparent regular pattern. The regional trend of northwest-striking faults can be seen in this zone, but the structure is complicated by many faults with other orientations, even some with arcuate patterns. Almost all the rocks clearly recognized as intrusive are in this zone. The alignment of the zone as a whole, furthermore, parallels the regional northwest trend of intrusive bodies and major faulting (McAnulty, 1955, p. 561).

The complexity of faulting in and around the zone of intrusion might have developed from either of two mechanisms: a series of local intrusions of slightly different ages; or several, distinct, localized surges during intrusion of one large body of magma. The first explanation is favored because several bodies of intrusive rocks of different compositions are present in the zone of intrusion.

Ignimbrites of the largest known volumes either are associated with collapse structures or their source areas are unknown (Smith, 1960a, p. 820). Recent workers in Norway (Rutten and Van Everdingen, 1961) have suggested that the Oslo rhomb porphyries may be ignimbrites. The Oslo rocks certainly are associated with a major subsidence structure, the Oslo graben (Barth, 1962, p. 207). Ignimbrites are, by far, the most abundant extrusive material in the Davis Mountains and represent the draining of a tremendous volume of magma from within the earth's crust. A major subsidence structure, or structures, thus can be expected in the source area, or areas, of the rocks. Whether such a subsidence structure exists beneath the Davis Mountains is not established but is thought to be probable because the intrusive zone in the central Davis Mountains is almost directly on a strike of about N. 30° W. with the central intrusive masses in the Big Bend depression (Baker, 1935, pp. 172–180). The Big Bend depression is about 35 to 40 miles across and has a vertical displacement of 4,000 to 6,000 feet below its northeastern and southwestern boundaries (Baker, 1935, p. 173).

STRUCTURE OF INTRUSIVE ROCKS

Joints and flow structures can be useful clues in determining the mode of intrusion of an igneous body, particularly where contacts are not exposed. Detailed, systematic studies of these features in the intrusive rocks of the central Davis Mountains have not been completed but are in progress as part of a study of the quartz microsyenite body of Sawtooth Mountain.

Several working hypotheses are worthy of consideration in future studies of joints and flow structures of the intrusive rocks: (1) The joints and flow structures may reflect upward intrusion of a body of magma. (2) They may result from lateral movement of magma as it forms a sill. (3) The joints may result from regional tectonic stresses. (4) They may be release fractures which form upon removal of overburden.

About 1 mile north of State Highway 166 in the southeast corner of the map area, two of the prominent joint sets in the quartz microsyenite are oriented N. 40° W. 82° E. and N. 15°–20° E. 76° W. These may represent shear sets resulting from a maximum principal stress oriented slightly east of south and steeply plunging to the north. Such an orientation of stress is compatible with forcible upward intrusion of a solid mass or a nearly solid body of magma.

The sub-radial joint pattern and the planar and linear flow structures in the quartz microsyenite at Sawtooth Mountain lend support to the hypothesis that the body is a sill. The "feeder" of the sill is probably at the southeast end of the mountain where the surrounding volcanic rocks dip inward up to 32° (cross section C-C′). Hempkins (1962, p. 102) interpreted this structure as a rim syncline which developed because of evacuation of the magma chamber of quartz microsyenite during intrusion. The inward dips probably did result from the evacuation of the magma chamber, but the presence of a complete rim syncline is not established because the rocks dip inward only on the southeast end of the body.

Joints approximately parallel to the regional fault trend probably have resulted from regional tectonic stresses. Steeply dipping joints which strike N. 35°–45° W. are found in quartz trachyte about 1 mile southwest of the benchmark on Mount Livermore. This orientation also is parallel to several chlorite latite dikes, one of which intrudes quartz trachyte and another of which intrudes quartz microsyenite.

One rather prominent joint set in quartz microsyenite at Sawtooth Mountain has the same attitude as the planar flow structure, about N. 50° W. 8°–12° S. This joint set probably resulted from pressure release at right angles to the plane of planar flow structure as overburden was removed during erosion.

STRUCTURAL EVIDENCE OF AGE RELATIONS

Exposed contacts which might resolve the question of relative ages of intrusive and extrusive rocks have not been found, except at one locality. In a stream bed outcrop at 30° 41.6′ N., 104° 12′ W., the Sheep Pasture Formation is cut by quartz microsyenite.

It has been possible neither to establish that the local intrusions were sources of most of the volcanic rocks nor to determine whether most of the volcanic rocks were erupted from vents in the central Davis Mountains or from elsewhere. Fault patterns in the central Davis Mountains suggest, however, that the intrusive rocks are younger than most, if not all, of the extrusive rocks. The volcanic rocks are cut by steeply dipping, generally northwest-striking, gravity faults throughout the area. Only in the generally northwest-trending belt of intrusive rocks are the volcanic rocks cut by many faults with other orientations. The regional northwesterly trend of faults is probably a result of regional tectonic stresses. The belt of intrusions also follows this trend, probably because the northwesterly direction represents a direction of weakness along which magma readily moved. The irregular array of faults in the intrusive zone is thought to be superposed on the older northwest-trending regional pattern of faults.

Hydrothermal silicification is probably younger, or at least no older, than the emplacement of quartz microsyenite. Linear trends of silicified rocks one-half mile south of Bloys Campground are roughly parallel to a joint set which cuts the quartz microsyenite nearby. The joint set strikes east-northeast and dips about 90°.

GEOLOGIC HISTORY

Laramide faulting provided avenues for upward movement of alkalic, monzonitic magma through Cretaceous sedimentary rocks. The magma probably formed by refusion of deeply buried, water-laden sediments. Rapid and violent escape of the more volatile constituents of the magma produced ignimbrites and air-fall tuff as the magma reached the low pressure conditions near the surface.

Explosive activity began during late Eocene or Oligocene time and continued for an undetermined, though probably geologically short, time span. The cessation of ignimbrite and air-fall tuff eruption has not been dated paleontologically, but little erosion took place between the successive pyroclastic deposits of the lower rhyolite, the upper rhyolite, the Sheep Pasture Formation, and the Wild Cherry Formation in the central Davis Mountains.

The volatile content of the magma generally decreased with time. The Merrill, Mount Locke, and Medley Formations, rock units with many characteristics intermediate between those of rhyolitic ignimbrites and of ordinary lava flows, were extruded late in the phase of explosive activity.

The ignimbrites were probably disgorged from a large number of fissures scattered throughout a region that includes the Big Bend depression on the southeast and the Davis Mountains area and the Sierra Vieja farther to the northwest.

Following the explosive stage of igneous activity was a period characterized by shallow intrusions of magma which ranged in composition from trachyandesite to quartz microsyenite. The intrusions were emplaced along a pre-existing northwest-trending zone of weakness.

During the intrusive phase of igneous activity, the older volcanic rocks were intensely faulted. The relative ages of most of the intrusive bodies are not accurately established, but the trachyandesite and latite of Mount Livermore are inferred to be the oldest.

The intrusions of quartz microsyenite and quartz trachyte probably occurred close together in time. It is also probable that the Goat Canyon and Brooks Mountain Formations, both of which are trachyte, were extruded one after the other at about the same time that the two intrusions were emplaced.

Following deposition of the Wild Cherry Formation and before deposition of either the Medley or Goat Canyon Formations, hydrothermal activity altered many of the pre-existing rocks. Hydrothermal solutions moved upward along fractures and spread laterally where possible. Highly siliceous rocks were most commonly produced in the southwestern part of the area, but, locally, kaolinite was produced. Kaolinite and nontronite were the most abundant products of hydrothermal activity in the northeastern part of the area but also were formed in other places. The original composition of the altered rock, rather than that of the altering solution, was the controlling factor in determining whether kaolinite or nontronite was formed.

The areally restricted "Eppenauer" basalt was erupted before deposition of the Wild Cherry Formation but was not noticeably affected by hydrothermal solutions. The vent from which it was emitted was probably in the northeastern part of the area.

Another basalt unit, the Jones Formation, was emplaced in the extreme southwestern part of the area and farther west. It was probably extruded no earlier than the "Eppenauer" basalt, and possibly a great deal later.

The Davis Mountains region has been dissected rather thoroughly by stream erosion since cessation of igneous activity. Sub-radial drainage has developed around the topographically high area defined by Mount Livermore and Sawtooth Mountain.

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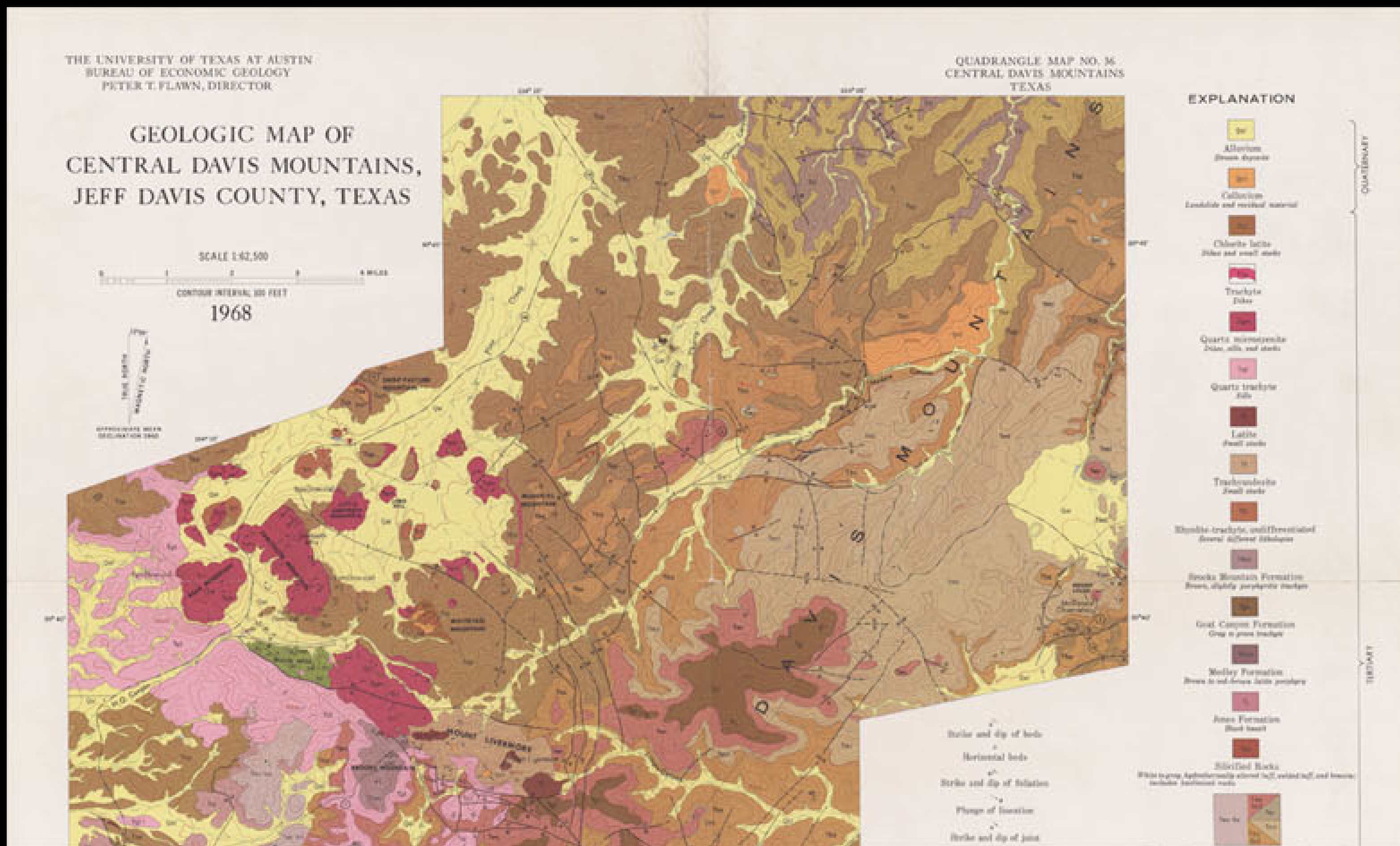
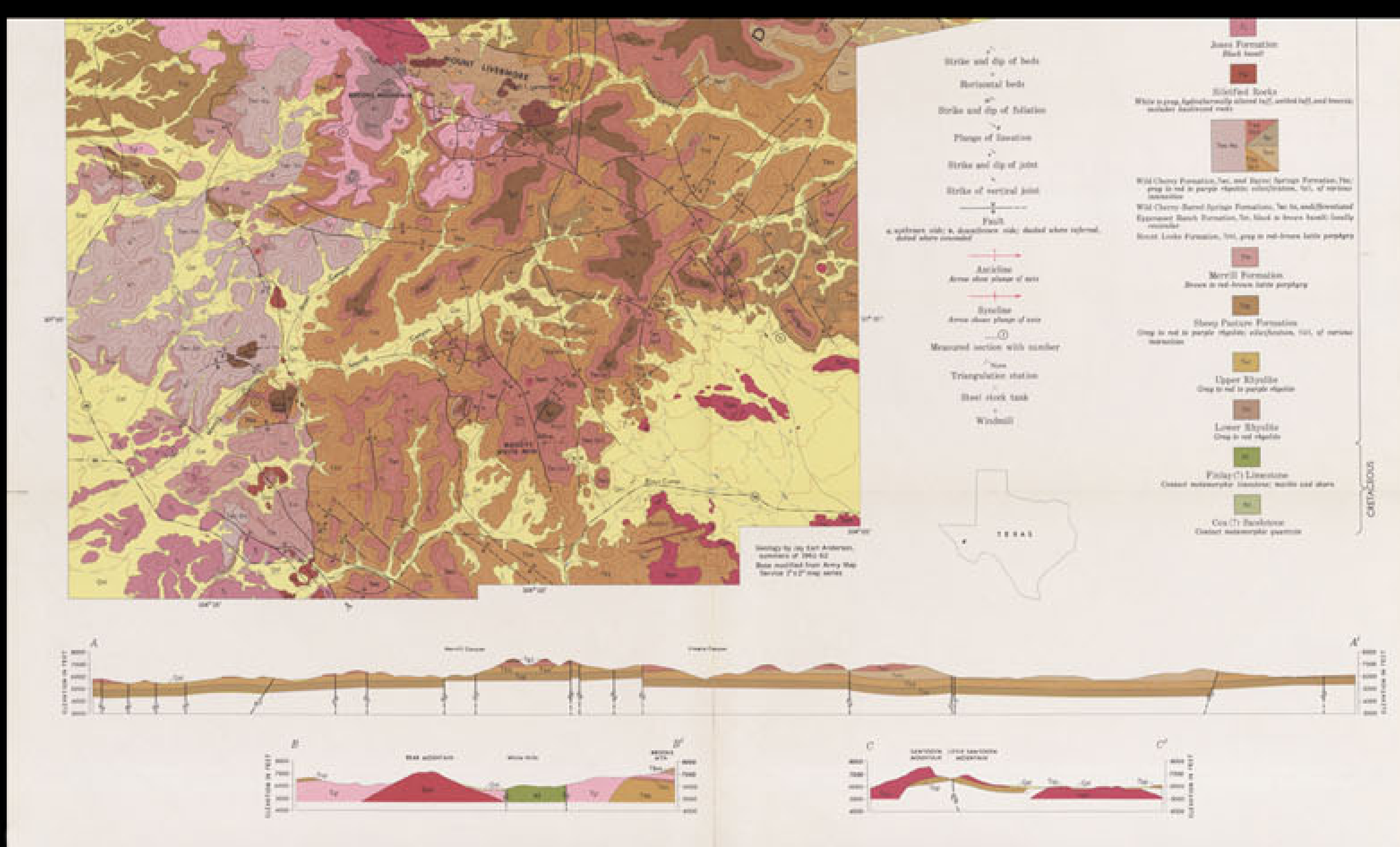


THE UNIVERSITY OF TEXAS AT AUSTIN
BUREAU OF ECONOMIC GEOLOGY
PETER T. FLAWN, DIRECTOR
QUADRANGLE MAP NO. 36
CENTRAL DAVIS MOUNTAINS
TEXAS
GEOLOGIC MAP OF
CENTRAL DAVIS MOUNTAINS,
JEFF DAVIS COUNTY, TEXAS
SCALE 1:62,500
CONTOUR INTERVAL 100 FEET
1968
DAVIS MOUNTAINS
MOUNT LIVERMORE
EXPLANATION
QUATERNARY
TERTIARY
Alluvium
Colluvium
Chlorite latite
Trachyte
Dikes
Quartz microsyenite
Quartz trachyte
Sills
Latite
Small stocks
Trachyandesite
Small stocks
Rhyolite-trachyte, undifferentiated
Brooks Mountain Formation
Goat Canyon Formation
Medley Formation
Jones Formation
Black basalt
Silicified Rocks
Strike and dip of beds
Horizontal beds
Strike and dip of foliation
Plunge of lineation
Strike and dip of joint



MOUNT LIVERMORE
Jones Formation
Black basalt
Silicified Rocks
Strike and dip of beds
Horizontal beds
Strike and dip of foliation
Plunge of lineation
Strike and dip of joint
Strike of vertical joint
Fault
Anticline
Syncline
Measured section with number
Triangulation station
Steel stock tank
Windmill
Merrill Formation
Sheep Pasture Formation
Upper Rhyolite
Lower Rhyolite
Finlay (?) Limestone
Cox (?) Sandstone
CRETACEOUS
TEXAS
A
A'
B
B'
C
C'
ELEVATION IN FEET

THE UNIVERSITY OF TEXAS AT AUSTIN
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QUADRANGLE MAP NO. 36
CENTRAL DAVIS MOUNTAINS
TEXAS

GEOLOGIC MAP OF CENTRAL DAVIS MOUNTAINS, JEFF DAVIS COUNTY, TEXAS

SCALE 1:62,500

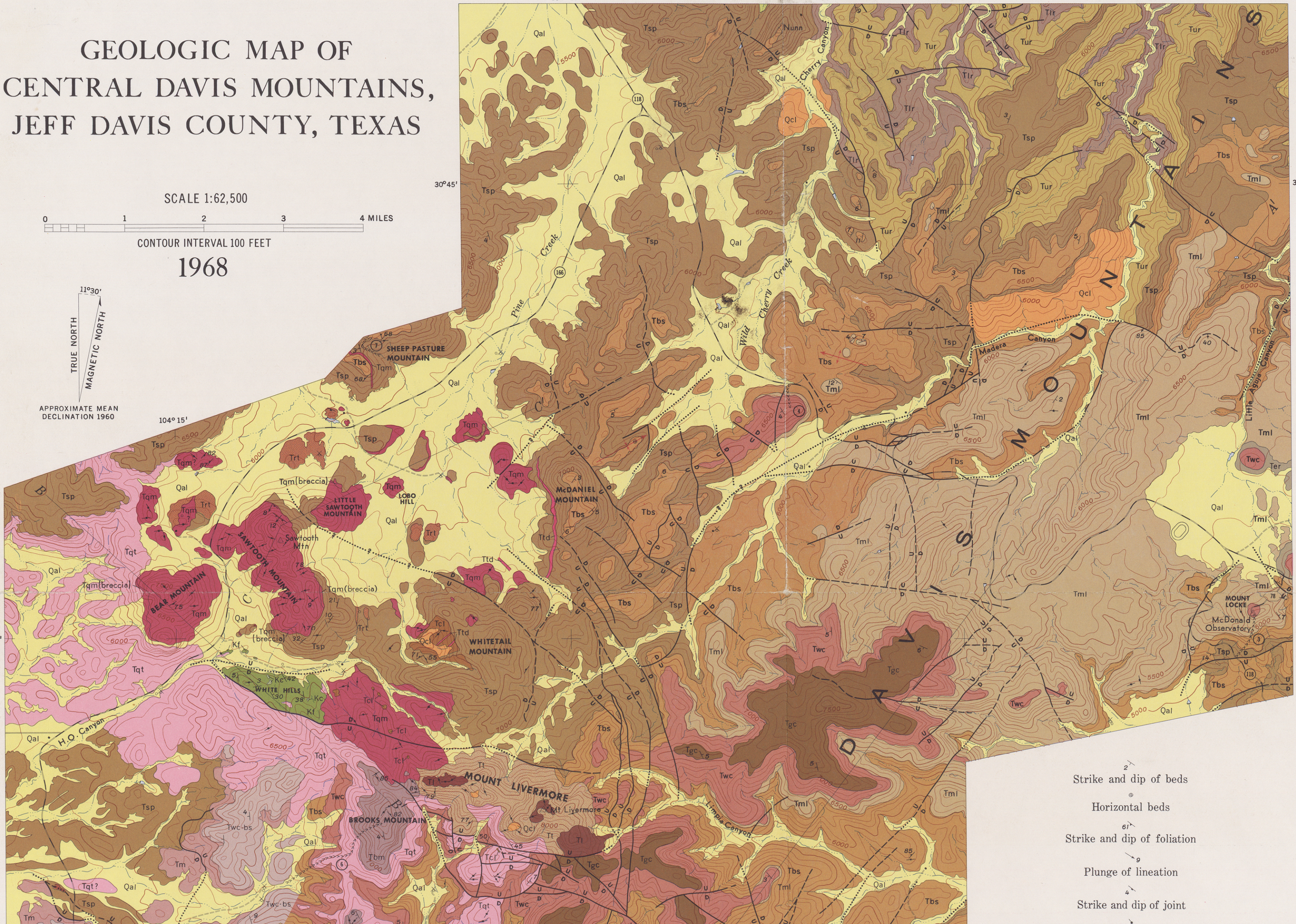
0 1 2 3 4 MILES

CONTOUR INTERVAL 100 FEET

1968

TRUE NORTH
MAGNETIC NORTH
11°30'

APPROXIMATE MEAN DECLINATION 1960



Strike and dip of beds

Horizontal beds

Strike and dip of foliation

Plunge of lineation

Strike and dip of joint

EXPLANATION

QUATERNARY

Qal — Alluvium
Stream deposits

Qcl — Colluvium
Landslide and residual material

TERTIARY

Tcl — Chlorite latite
Dikes and small stocks

Ttd — Trachyte
Dikes

Tqm — Quartz microsyenite
Dikes, sills, and stocks

Tqt — Quartz trachyte
Sills

Tl — Latite
Small stocks

Tt — Trachyandesite
Small stocks

Trt — Rhyolite-trachyte, undifferentiated
Several different lithologies

Tbm — Brooks Mountain Formation
Brown, slightly porphyritic trachyte

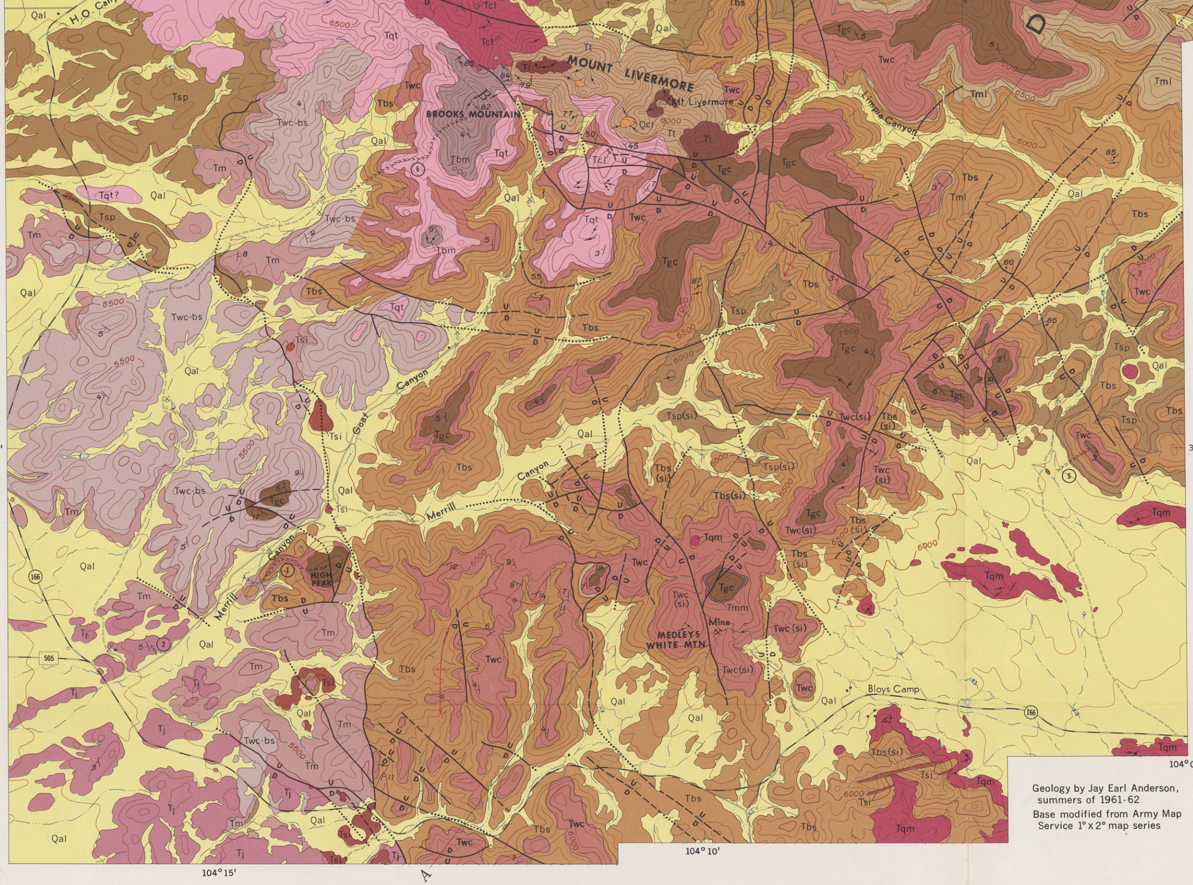
Tgc — Goat Canyon Formation
Gray to green trachyte

Tmm — Medley Formation
Brown to red-brown latite porphyry

Tj — Jones Formation
Black basalt

Tsi — Silicified Rocks
White to gray, hydrothermally altered tuff, welded tuff, and breccia; includes kaolinized rocks

Twc (si) | Ter | Twc-bs | Tml | Tbs (si)



Geology by Jay Earl Anderson, summers of 1961-62
Base modified from Army Map Service 1° x 2° map series

Strike and dip of beds

Horizontal beds

Strike and dip of foliation

Plunge of lineation

Strike and dip of joint

Strike of vertical joint

Fault

U, upthrown side; D, downthrown side; dashed where inferred, dotted where concealed

Anticline

Arrow show plunge of axis

Syncline

Arrow shows plunge of axis

Measured section with number

Triangulation station

Steel stock tank

Windmill

Tj — Jones Formation

Black basalt

Tsi — Silicified Rocks

White to gray, hydrothermally altered tuff, welded tuff, and breccia; includes kaolinized rocks

Twc-bs; Twc (si); Ter; Tml; Tbs (si)

Wild Cherry Formation, Twc, and Barrel Springs Formation, Tbs; *gray to red to purple rhyolite; silicification, (si), of various intensities*

Wild Cherry-Barrel Springs Formations, Twc-bs, *undifferentiated*

Eppenauer Ranch Formation, Ter, *black to brown basalt; locally vesicular*

Mount Locke Formation, Tml, *gray to red-brown latite porphyry*

Tm — Merrill Formation

Brown to red-brown latite porphyry

Tsp — Sheep Pasture Formation

Gray to red to purple rhyolite; silicification, (si), of various intensities

Tur — Upper Rhyolite

Gray to red to purple rhyolite

Tlr — Lower Rhyolite

Gray to red rhyolite

Kf — Finlay (?) Limestone

Contact metamorphic limestone; marble and skarn

Kc — Cox (?) Sandstone

Contact metamorphic quartzite

CRETACEOUS